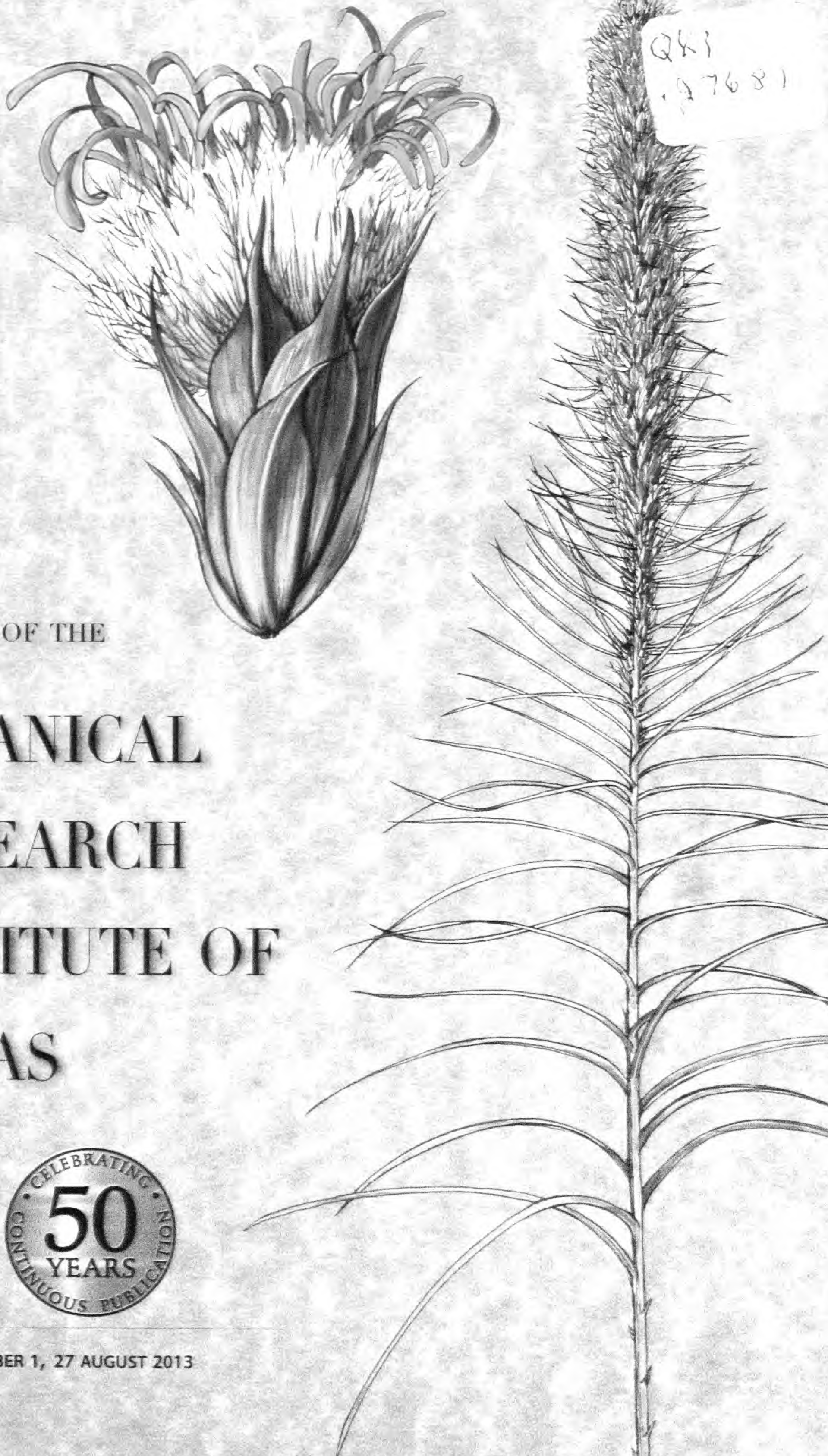
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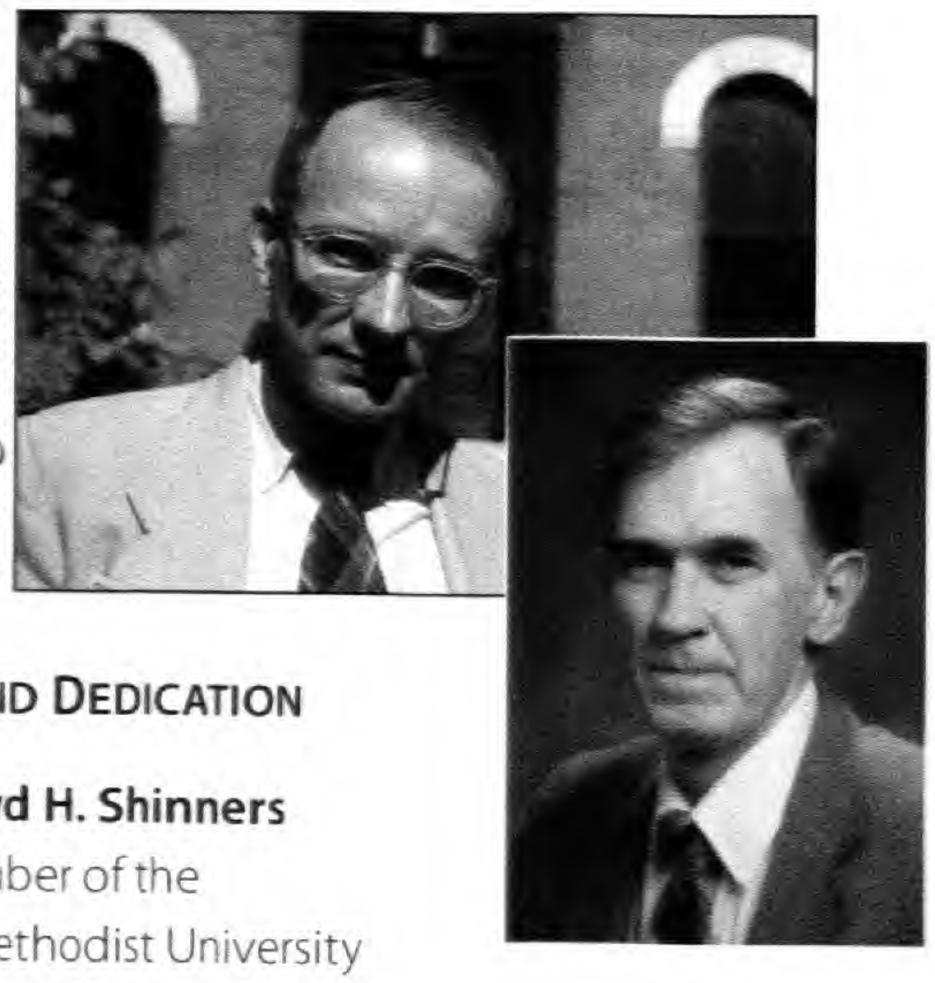
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A NEW LEATHERFLOWER (*CLEMATIS*: RANUNCULACEAE) FROM THE SOUTHERN APPALACHIANS

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ABSTRACT

Clematis vinacea sp. nov., a new, narrowly endemic species of *Clematis* subg. *Viorna* is described and illustrated from the southern Appalachian Mountains of the southeastern United States. Its relationship to *C. crispa*, based on habit, morphology, and phenology is discussed. Its limited distribution is discussed in relation to the Walden Creek geologic formation to which it seems restricted.

RIASSUNTO

Clematis vinacea sp. nov., una nuova, specie strettamente endemiche di *Clematis*, sottogenere *Viorna* è descritto ed illustrato dalle Appalachi meridionali del sud-est degli Stati Uniti. Il suo rapporto con *C. crispa*, sulla base di abitudine, morfologia e fenologia è discusso. Sua distribuzione limitata è discusso in relazione alla formazione geologica Walden Creek cui sembra ristretta.

INTRODUCTION

Several populations of a *Clematis* L. (Ranunculaceae) with affinities to *C. crispa* L. were observed growing on shale talus slopes in the Ocoee River Gorge in Polk County, southeast Tennessee; an unusually dry habitat for *C. crispa*. The plants were vining through neighboring vegetation with flowers at the terminus of each stem, but lacked the broadly crispate sepal margins seen in *C. crispa*. Plants observed during anthesis in early spring bore an uncanny foliar and habit resemblance to the western North American *C. hirsutissima* Pursh. These plants were erect, the lower leaves reduced to linear-lanceolate segments, and the inflorescence was terminal and single-flowered with pinkish-purple, sericeous sepals. The three to five pairs of opposite leaves were highly divided and densely sericeous on both surfaces. Additional observations later in the season showed that the plant can continue to grow from axillary buds at the base of the terminal inflorescence. When edaphic conditions, i.e., abundant soil moisture, are present throughout the season the plant continues growing whereupon the habit becomes vine-like.

Examination of herbarium materials at TENN shows that *Clematis vinacea* has long been confused with the Appalachian forms of *C. viorna* L. which are glabrous in comparison to the pubescent forms encountered in the Interior Low Plateau. Despite the similarities of the vestiture of *C. vinacea* to some *C. viorna* forms there are differences in the narrower leaflets and lobes, the sericeous vestiture on the leaves, stem, and sepals, and the distinctly abaxially and adaxially pinkish-purple colored sepals. It is likely that the distribution of this species, which is outside the range of *C. crispa*, has partly contributed to its inclusion within the sympatric *C. viorna*. Nonetheless, the phenology of *C. vinacea* begins in early spring (see type collection date in late March) and flowers throughout the growing season whereas *C. viorna* begins flowering in late May where the two are sympatric. Both *C. vinacea* and *C. viorna* share plumose achene tails, however, the achene tails are gold plumose in *C. vinacea* whereas they are typically brownish to whitish in *C. viorna*. Notwithstanding the confusion of this new species with *C. viorna*, the presence of the terminal ebracteate inflorescences, sepals colored on both surfaces, and growth habit suggests a close phenetic relationship to *C. crispa*. Despite their shared morphology, the plumose achene tails, leaf indument that is usually lacking in *C. crispa*, and the only slightly crispate sepal margins of *C. vinacea* differ strongly from *C. crispa*.

This new species falls within *Clematis* subg. *Viorna* Gray based upon the thick, leathery connivent sepals

which are urceolate and usually pendent (Pringle 1997). A common vernacular name for the group is "leather-flower." *Clematis* (Ranunculaceae) is a large genus comprising approximately 350 species (Wang 2005). Infrageneric classifications have been based partly on floral morphology (Tamura 1967, 1995; Keener & Dennis 1982), floral and leaf morphology and plant growth habit (Erickson 1943), and a combination of the above and eophyll orientation (Yang & Moore 1999; Wang 2005). Wang's (2005) recent subclassification recognizes subgenera, subsections and series, of which our southeastern leather-flowers would fall under *Clematis* subg. *Viorna* A. Gray, sect. *Viorna* (Reichb.) Prantl, subsect. *Crispae* Prantl which is subdivided further into five serial divisions. Pringle (1997) includes 25 species in *Clematis* subg. *Viorna* with 18 of these present in North America. I follow this broader subclassification. As part of a revision of the North American *Clematis* subg. *Viorna* (Estes, Floden, & Witsell, in prep.), examination of herbarium specimens and cultivation of nearly all eastern North American *Clematis* subg. *Viorna* have provided data supporting the recognition of *C. vinacea*, which appears to be endemic to a small region of the southern Appalachians.

TAXONOMIC TREATMENT

Clematis vinacea Floden, sp. nov. (**Fig. 1**). TYPE: UNITED STATES. TENNESSEE: POLK CO.: Ocoee River, shale banks along Hwy 64/40, just west of Caney Creek around bend on N-side of road on moist phyllite talus slopes that tend towards subxeric during summer, anthesis early spring and continuing through summer when moisture is available, 27 Mar 2012, *A. Floden 1942* (HOLOTYPE: TENN; ISOTYPES: APSC, BRIT, MI, MO, NCU, NY, TENN, UTC, others to be determined).

Differs from *Clematis viorna* in the presence of terminal flowers without bracts; and differs from *C. crispa* in its sericeous pubescence, plumose achene tails, minimally expanded or non-expanded sepal margin, and upland subxeric habitat preference vs. the bottomland, floodplain habitat of *C. crispa*.

Plants: perennial from a rootstock with several thick roots, frequently with short horizontal rhizomes, some plants with 2 or more stems; stems 25–150+ cm, erect early in season becoming scandent to vining later, stems 6 angled, 12 ribbed, castaneous, shortly sericeous to glabrate in age. **Leaves:** opposite, decussate, imparipinnate to pinnate-ternate, largest at midstem, spreading, to 1–3 dm long, longer than wide; petioles slender, subequal to lowermost leaflets, 1–6 cm long, sericeous pubescent; leaflets symmetrical or asymmetrical, 8–12 cm long on imparipinnate leaves, to 30 cm on midstem pinnate-ternate leaves, leaflets 3–5-lobed, rarely unlobed, or 3 foliolate, 3–7 × 1–3 cm, bases cuneate to rounded-truncate, apices abruptly obtuse-mucronate, texture chartaceous, proximal leaves with narrow segments frequently less than 1 cm, reduced on rachis, sometimes terminating in a tendril-like petiolule with a small elliptic leaflet; shortly sericeous abaxially, sometimes sericeous adaxially, margins ciliate, revolute. **Inflorescences:** terminal (primary stem or branch), ebracteate, 1-flowered, branches with inflorescences borne from base of terminal peduncle sometimes bracteate in late season stems, bracts ovate to trilobed, 0.5–2 cm. **Flowers:** bisexual; sepals 4 erect, valvate, connivent, oblong, oblanceolate, perianth urceolate; sepals colored adaxially and abaxially, pinkish-purple, reddish or pinkish, drying brownish, apices lighter pink, green or white; densely sericeous; 1.5–3 × 0.6–1.5 cm, ovate-oblong, apex acuminate, recurved, margins white sericeous; stamens linear, filaments flattened, anthers oblong or narrowly oblong, 4–5 mm long, connectives pubescent to apex, extended 0.5–1.5 mm beyond anther; stigmas 10–14 mm long, apex papillose and curved, plumose. **Infructescences:** spherical, 3–7 cm diam., achene tails curvate, plumose trichomes golden. **Achenes:** flattened, orbicular, brown, shortly sericeous; 4–6 mm, tails 3–5 cm, trichomes to 5 mm proximally, shorter distally.

Flowering: March-September, fruiting June–October.

Other specimens examined: **GEORGIA. Murray Co.:** 29 Apr 1986, *N.C. Coile 4621 w L. & G. Foote, S.B. Jones, & H. Currie* (TENN). **TENNESSEE. Polk Co.:** Ocoee River Gorge; 9 May 2004, *M. Rhinehart s.n.* (TENN); 8 Jun 1958, *A.J. Sharp, F.H. Norris, & N. Russell 23650* (TENN); 21 May 1961, *A.J. Sharp & J.S. Pringle 28541* (TENN); 3 May 1989, *V.E. McNeilus 89-208* (TENN); 9 May 1977, *E. Wofford & D.H. Webb 77-62* (TENN); 19 May 1963, *Mr. & Mrs. A.J. Sharp, G. Jones, C. Varner, & G. Ramsey 31297* (TENN); 5 Jun 2009, *A. Floden 913* (TENN); 10 May 1959, *G. Carter & R. Houk 25778* (TENN); 10 May 1959, *G. Carter & R. Houk 25770* (TENN); 20 May 1986, *E. Schell s.n.* (TENN); 1 May 1976, *T.S. Patrick & R.W. Simmers s.n.* (TENN); 18 Apr 1980, Hiawassee River Gorge; *W. Manek 88* (TENN); 17 Apr 1949, *A.J. Sharp, C.J. Felix, & B. Adams 11369* (TENN).



FIG. 1. Holotype (left) and an isotype (right) of *Clematis vinacea* at TENN. The holotype shows the axillary buds that become scandent at the base of the terminal inflorescence and the isotype shows the distinctive rhizome. Scale bar = 2 cm.

DISCUSSION

Living material of *Clematis vinacea* was first observed by the author in early June 2009 that was in anthesis while also bearing nearly mature gold-plumose achenes. Notable features were the dense sericeous pubescence of the pinkish-purple sepals, stem and leaves, and the leaves with more numerous and narrower leaflets than *C. viorna* (Fig. 1). Although annotations have consistently placed *C. vinacea* within the concept of *C. viorna* or *C. crispa*, specimens of *C. vinacea* at TENN are easily segregated from the former by their terminal flowers borne on ebracteate pedicels and narrower leaves and from the latter by the sericeous indument of the leaves and sepals and plumose achene tails. Furthermore, the habit of *C. vinacea* due to continued growth in response to sufficient moisture enables the plants to become vining later in the growing season whereas collections early in the season appear distinctly erect with a single terminal flower. A number of collections state the plant as "rather shrub-like" or "erect" which has been observed by the author both *in* and *ex situ*. Observations of *C. viorna* in the field show that its inflorescences are strictly axillary and begin in late May on distinctly vining plants. In contrast, early flowering does occur in *C. crispa*, but the plants are distinctly scandent and glabrous. The late season collections of *C. vinacea*, despite their terminal ebracteate inflorescences, have contributed to the confusion of this species with *C. viorna*.

Based on similarities in morphology and phenology, the phylogenetic relationship of *Clematis vinacea* seems to be with other terminally flowered *Clematis* of subg. *Viorna*; those from the American southwest and southeast. On a phytogeographic basis a close comparison can be made with *C. crispa* rather than the morphologically comparable western *C. hirsutissima*. It shares with *C. crispa*, *C. baldwinii* Torr. & A. Gray, and *C. socia-*

lis Kral several distinctive morphological and phenological characters: 1) ebracteate primary peduncles borne at the terminus of a stem or branch; 2) sepal margins with narrowly to broadly expanded crispate margins; and 3) early-spring flowering. In morphology, *C. vinacea* appears closest to its eastern counterpart *C. crispa*, but the two are easily separated on account of their sepal morphology (narrowly or not crispate vs. broadly crispate) and their achenes (plumose vs. non-plumose), respectively. Comparison of cultivated plants of *C. hirsutissima* also shows similarities: a strongly clump forming habit from a short horizontal rhizome; finely divided lower leaves; and terminal inflorescences, though the indument observed in *C. hirsutissima* is denser than that seen in *C. vinacea* to nearly hoary in some parts of its distribution (Pringle 1997).

Observations of several genets of both *Clematis vinacea* and *C. crispa* cultivated in a common garden reveal that both exhibit similar growth patterns. Both display remontant behavior in response to ideal edaphic conditions where the axillary buds subtending each terminal, single-flowered inflorescence enable continuous growth and flowering throughout the growing season. Populations of *C. vinacea* were observed in flower on vine-like plants from early spring through September during 2009, 2010, and 2012. Field observations in 2011 revealed that during drought conditions *C. vinacea* remains a single stemmed, once flowering perennial. In cultivation *C. socialis* and the western *C. hirsutissima* have not shown any remontant tendency, but have continued limited vegetative growth after their spring flowering. Both are erect perennials with short to long branching rhizomes (Kral 1982). Rhizomes have been observed in several populations of *C. vinacea* where single clones can have up to 12 or more stems separated by several centimeters each (Fig. 1), whereas rhizomes are not present on *C. crispa*.

Perianth morphology of *Clematis* subg. *Viorna* differs little between taxa; all are 4-sepaled, urceolate, and valvate and connivent most their length. Perianth color varies between species, and can even vary dramatically within a species, although not usually within a population. *Clematis crispa* has broadly crispate sepal margins and this character has led to its monotypic subsectional status within the broader subg. *Viorna* (Grey-Wilson 2000). Nonetheless, several other taxa not included in this subsectional division are notable for their crispate sepal margins as well: *C. baldwinii; C. socialis; C. hirsutissima;* and some forms of *C. pitcheri* Torr. & A. Gray from the southwestern part of its range. *Clematis vinacea* differs from its phytogeographic neighbors by not having prominent crispate sepal margins. Furthermore, the presence of plumose achene tails differs strongly from the short, glabrous (non-plumose) achene tails on *C. crispa*. Plumose achene tails are shared with *C. baldwinii*, but that species is distinctly erect without a tendency to vine. The presence of the plumose achenes on *C. vinacea* is also a likely contributor to the misidentification of specimens as *C. viorna* because it also exhibits this character and is sympatric in distribution. But, the gold plumose achene tails differ from the typically brownish achene tails of *C. viorna*.

GEOGRAPHIC DISTRIBUTION

The majority of collections of *Clematis vinacea* are from the Ocoee River Gorge, a scenic and much botanized area, but where most collections are confined to easily accessible roadside localities due to the nature of the gorge; steep cliff faces composed of siliceous phyllite slopes that are difficult to access. All known populations in Tennessee are limited to the Walden Creek geologic formation which is a narrow band (<15 km wide) nestled between the Smoky Mountain group geologic formation to the east and west (Hardeman 1966). Within this narrow band along the Ocoee River *C. vinacea* is extremely abundant where road construction has facilitated increased erosion of the slopes and produced an abundance of available habitat. It is known from two areas along the Hiwassee River to the north: near the mouth of the gorge along Spring Creek; and further up-river near the abandoned community of McFarland. A single collection from southeastern Murray Co., Georgia was collected on limestone bluffs above the Coosawattee River (see specimens examined). It is likely that other reported occurrences of *C. crispa*, and potentially *C. viorna*, from dry habitats in northernmost Georgia are *C. vinacea*.

In addition to differing in morphology, *Clematis vinacea* and *C. crispa* occur in distinctly different habitats. *Clematis vinacea* is a plant of relatively dry talus slopes, cliff ledges, calcareous-phyllite woodlands, and



Fig. 2. *Clematis vinacea* in flower after early summer wild fires in situ, August 2012 (Photo: A. Floden).

bluffs and outside the preferred habitat of *C. crispa* which inhabits bottomlands throughout the Coastal Plain of the southeastern United States from Virginia south and west to east Texas and up the Mississippi embayment to Illinois and Missouri.

Within its narrow range, *Clematis vinacea* is sympatric with two native species and one introduced species of *Clematis*. *Clematis viorna* is present on Big Frog Mountain just to the south of the Ocoee River at higher elevations and is also present along the Hiwassee River to the north. *Clematis viorna* is not known to occur syntopically with *C. vinacea* on either river system. I have observed *C. viorna* in only two locations along the Hiwassee where it occupies distinctly different habitats from *C. vinacea*; particularly mesic riparian zones where it often scrambles through low shrubs. *Clematis glaucophylla* Small is rare in Tennessee, but at one site along the Ocoee River it is growing within a few meters of a large population of *C. vinacea*. Throughout the Ocoee River Gorge the introduced and invasive *C. terniflora* DC is abundant with populations of *C. vinacea*.

The southern Appalachians, including the Ocoee and Hiwassee River areas, are notable for numerous rare and endemic taxa, e.g. *Coreopsis latifolia* Michx., *Gaylussacia ursina* (M.A. Curtis) Torr. & A. Gray ex A. Gray, *Pityopsis ruthii* (Small) Small, *Pycnanthemum curvipes* (Greene) E. Grant & Epling, *Sedum nevii* A. Gray, and *Vaccinium hirsutum* Buckl. (Harper 1941; Wood 1970). Additional taxa that appear to be endemic to this area are undescribed species of the genera *Stachys* and *Monarda* (Floden, in prep.). The Ocoee River and Hiwassee Rivers in Tennessee also support numerous rare taxa, some of which are not shared between the two river systems: *Lysimachia fraseri* Duby, *Helianthus smithii* Heiser, *Isoetes tennesseensis* N.T. Luebke & J.M. Budke, and *Viburnum carolinianum* Ashe. Most of these are known from the Walden Creek geologic formation where *Clematis vinacea* is found.

The summer of 2012 offered a glimpse at an ecological adaptation of *Clematis vinacea* to its subxeric habitat. Early summer drought led to wildfires in June in a large portion of the Ocoee River Gorge habitat where *C.*

vinacea occurs. Most of the shrubby layer was killed to the ground and many herbaceous plants were killed outright. Surprisingly, *C. vinacea* responded quickly to mid-summer rains and was in full flower by mid-August as the predominant plant in several burned areas (Fig. 2). Excavation of several plants showed the root crown was positioned 15–20 cm below the soil surface. The deeply positioned root crown is likely an adaptation to the subxeric habitat that also provides protection from the occasional fire.

SUGGESTIONS FOR COLLECTING *CLEMATIS* SPECIMENS

A lack of material or too much plant material folded over itself on herbarium specimens can obscure the distinct characters of a collection of *Clematis* subg. *Viorna*. Morphology can also be misinterpreted when material for preservation is taken from the proximal to middle part of the stem rather than a terminal section. Therefore, collectors should note from which part of the plant the material has originated if it is not obvious, especially the vining taxa, and also seek to press the whole stem in sections. The position of the bracts on the peduncle should not be obscured by the leaves. Furthermore, the perianth color of *Clematis* herbarium material is usually masked upon desiccation by turning brown (Keener 1975; Dennis 1976). Variation in color of the sepals can differ between early season flowers and those produced later in the season. I have observed this *in situ* and *ex situ* which has also been confirmed by D. Estes (pers. comm.). Noting the color, or providing a photograph of the sepals, despite their variability, is useful in some groups, e.g. Glaucophylla-group, and Viorna-group.

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BOOK REVIEW

MICHAEL WOJTECH. 2011. **Bark: A Field Guide to Trees of the Northeast.** (ISBN: 978-1-58465-852-8, hbk). University Press of New England, 1 Court Street, Lebanon, New Hampshire 03766, U.S.A. (**Orders:** www.upne.com, 1-800-421-1561, 1-603-448-9429 fax). $25.95, 280 pp., 65 maps, 434 illus. (283 color), keys, 5 ½" × 8 ¾".

Bark: A Field Guide to Trees of the Northeast is divided into six chapters: instructions on how to use this particular guide, bark structure, bark types, secondary identification keys, bark ecology, and species. This book consists of numerous color images, line drawings, keys, and maps that provide the reader with further information about the trees that one would encounter in the forests of the Northeastern U.S.A.

The opening chapter provides information on how a potential reader would begin to use this field guide. The two chapters that follow contain detailed information regarding the structure and types of bark that can be found in this area. Bark can have a variety of appearances: smooth, peeling, curling, cracking, scales, plates, ridges, etc. These features can help the reader determine which species is in front of them. The author includes line drawings for each description as well as 1–2 images of actual trees with these bark types. Also included is a U.S.A. quarter in each photograph to establish a standard scale for each feature shown. Wojtech also included a chapter on bark ecology to help the reader further understand the diversity and function of bark.

Wojtech included two keys within this book. The primary key is printed on the inside cover. This key will help you determine which part of the secondary key you should visit to further investigate the species. Cleverly, he includes prefixes within the secondary key section to designate the age of the tree: young (Y), mature (M), and old (O). This is important since bark appearance can change as the tree ages.

The largest chapter within the book contains species accounts. Wojtech includes two pages per species that list the dominant common name, other possible common names, family name, and Latin binomial. He then provides a brief description of the habitat and any notes that the reader should take into account for the particular species. Each species has a line drawing of a branch and leaf or leaflet, a distribution map, and 2–3 images of the bark at varying ages.

This book would make a great, lightweight field guide that any person would want to include when hiking in the Northeastern U.S.A. The images provide a clear view of the species rendering them useful for identification. Bark is the one item that does not disappear and is present through each season. It is nice to see someone use this particular aspect of trees to help properly identify them in the field.—*Keri M. Barfield, MS Biology, Research Programs Manager, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

VIOLA CALCICOLA (VIOLACEAE), A NEW ENDEMIC VIOLET FROM THE GUADALUPE MOUNTAINS OF NEW MEXICO AND TEXAS

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ABSTRACT

Viola calcicola is described as growing in limestone located within protected springs and valleys of the Guadalupe Mountains in New Mexico and Texas. This violet is most similar macromorphologically and ecologically to *V. egglestonii* of east-central U.S. limestone cedar glades and micromorphologically to *V. septemloba* of southern Atlantic and Gulf Coast sand pine savannas. However, it diverges from all known heterophyllous-leaved taxa of *Viola* subsection *Boreali-Americanae* in many vegetative and reproductive features. It is removed by hundreds of kilometers from other putatively related heterophyllous-leaved violets, being the first record of lobed-leaved members of the subsection in the western U.S. and the second species of *Viola* found to be endemic to the Guadalupe Mountain region.

RESUMEN

Se describe **Viola calcicola** como una planta que crece en piedra caliza alrededor de manantiales y valles protegidos en la sierra de Guadalupe de Nuevo México y Texas. Esta violeta es muy similar macro morfológica y ecológicamente a *V. egglestonii* de la parte este-central de Estados Unidos en la región conocida como "cedar glades", y micro morfológicamente a *V. septemloba* de la costa sur Atlántica y de las sabanas arenosas de la costa del Golfo, pero difiere de éstas y del resto de las violetas con polimorfismo foliar de la subsección *Boreali-Americanae* en muchos caracteres vegetativos y reproductivos. Espacialmente esta separada por miles de kilómetros de cualquier otra violeta con polimorfismo foliar, siendo este el primer registro de una especie de este tipo en el oeste de Estados Unidos y la segunda especie de *Viola* endémica a la sierra de Guadalupe.

KEY WORDS: *Viola*, Violaceae, Guadalupe Mountains, new species, endemic, *Boreali-Americanae*

INTRODUCTION

Over the last half-century, three taxonomic treatments of North American (primarily U.S. and Canadian) *Viola* (Violaceae) have been proposed by specialists (Russell 1965; McKinney 1992; Gil-ad 1997). These differ substantially in the circumscription, rank, nomenclature and general evolutionary status of several taxa. In these and earlier treatments, specialists have noted two broad groups of taxa with notched, lobed, or divided leaves: homophyllous violets in which all leaf blades are lobed or divided throughout the growing season, and heterophyllous violets which produce undivided blades in the earliest and latest months of the growing season and notched, lobed or dissected leaves during the height of anthesis and into chasmogamous fruit. All three most recent treatments recognize some heterophyllous-leaved taxa, namely *V. egglestonii* Pollard, *V. septemloba* Leconte and *V. triloba* Schwein., at some taxonomic rank. Russell maintained the first three as well as *V. esculenta* Elliott, *V. lovelliana* Brainerd and *V. viarum* Pollard, as distinct species. McKinney synonymized the latter three along with *V. triloba* Schein. within a broadly delimited heterophyllous taxon under the name *V. palmata* L., based on his interpretation that the type of Linnaeus' violet referred to a heterophyllous rather than a homophyllous violet. Gil-ad used the presence of unique or extreme macromorphological characteristics, and micromorphological features in seed coat sculpturing and lateral beard trichomes (Gil-ad 1998), to infer orthospecies status for *V. egglestonii*, *V. septemloba* and *V. triloba* but relegated *V. esculenta*, *V. lovelliana*, and *V. viarum* to hybrid derivatives based on intermediacy of various features. He provided a complete description and illustration of eastern Mexican *V. nuevo-leonensis* W. Becker as a heterophyllous-leaved member of the subsection. Non-specialists have run the gamut in their recognition of these violet taxa in North America. Gleason and Cronquist (1991) took McKinney's broad circumscriptions even further by merging nearly all heterophyllous-leaved and homophyllous-leaved violets into a single taxon as well as synonymizing most homophyllous-

leaved violets. The forthcoming treatment (co-authored by McKinney and R.J. Little) for the *Flora of North America* series will remain largely faithful to McKinney's original revision. The Biota of North America Program website (www.bonap.org, Kartesz 2011) and the USDA Plants Database website (http://plants.usda.gov/java/) follow Gil-ad's taxonomy. Recently published regional and state floras, and checklists, follow either extreme or a middle ground borrowing from both.

Specimens of a *Viola* clearly belonging to subsection *Boreali-Americanae* have been collected occasionally throughout the Guadalupe Mountains, but their identity has engendered taxonomic confusion. Spellenberg et al. (1986) ascribed a series of blue-flowered collections from three canyons in Eddy County, New Mexico by P.J. Knight to *V. viarum* Pollard, noting the large (800 km) range extension eastward to Oklahoma, the westernmost limit of its main range. This interpretation of an apparently disjunct population for an otherwise central U.S. species was proposed in light of other relict species also disjunct in the Guadalupes from their main southeastern hardwood forest ranges, although Spellenberg et al. acknowledged that further study might show the acaulescent blue Guadalupe violet to be unique. Subsequent annotations of specimens by other taxonomists and violet specialists have included *V. lovelliana* E. Brainerd, *V. missouriensis* Greene, and *V. palmata* L. (Worthington 2002).

The Guadalupe violet's unusual short vertical rhizome, sporadically heterophyllous nature, variable near-white to moderately purple corolla, and restriction to limestone substrate in the region initially attracted the attention of the authors. Examinations of specimens in herbaria with substantial Guadalupe Mountain angiosperm collections (NMC, SRSC, TEX/LL, and UNM), coupled with field studies of populations in New Mexico and Texas, have revealed that all collected material with whitish to purplish flowers in the Guadalupe Mountain region belongs to a single taxon, one that is distinct from previously described *Viola guadalupensis* with yellow flowers (belonging to sect. *Chamaemelanium*) in the same region. Plants within a given site encompass a broad range of leaf morphologies, with many plants bearing only unlobed leaves and others producing mid-season leaves with marginal notches or shallowly to moderately lobed blades (rarely, the largest blades are as deeply divided as typical *V. egglestonii*). Furthermore, plants at the lowest elevations in a given site usually possess purple corollas, whereas plants at the top of the same canyon often bear pale violet to nearly white ones.

Scanning electron microscopy was conducted in order to document micromorphological characters found to be taxonomically informative by Gil-ad (1998) in other acaulescent blue violets. Lateral petals and mature seeds were removed from herbarium specimens of *Viola calcicola*. One lateral petal was removed from each of two specimens, *Knight & Fletcher 3419* (UNM) and *Warnock & McVaugh 5418* (SRSC), and cropped to the immediate area around the trichomes before mounting. Two mature seeds from each of two specimens, *Warnock* 23336 (SRSC) and *Warnock & Johnston 16536* (SRSC), were prepared following the methods of Gil-ad (1998). Samples were mounted onto carbon tape on separate aluminum stubs and coated with gold palladium at 17 mA for 180 sec. Examinations were performed at The Ohio State University Microscopy and Imaging Facility using an FEI NOVA™ nanoSEM 400 scope. Descriptions and measurements of micromorphological characteristics of petal trichomes and seeds followed Gil-ad's terminology and methods (1998).

Table 1 details distinctions of *V. calcicola* in macromorphological and micromorphological features, in comparison with the four other heterophyllous-leaved species recognized by Gil-ad (1997). The new species diverges from other known species in many macromorphological features: rhizome, foliage, flowers, capsules, and seeds. The combination of these traits is wholly different from any known taxon and expresses a number of extreme features relative to the four previously described species. The main suite of macromorphological features encompasses its typically vertical praemorse rhizome, glabrous foliage, usually broad obtuse to rounded eciliate sepals, beardless spurred petal, sparse lateral petal beard with trichomes (sub)clavate to knob-shaped and cucullate, short green cleistogamous capsules on erect to declining peduncles, and yellow-brown to yellowish olive-brown seeds with darker brown patches. Study of the character states in Table 1 demonstrates that the number of overlapping or shared features between the new violet and other currently recognized heterophyllous-leaved orthospecies is far fewer than the number shared among the other four heterophyllous-leaved species. Its unusual vertical rhizome, sporadically heterophyllous nature, and expanded to

TABLE 1. Comparison of significant morphological features in *Viola calcicola,* sp. nov. and four other North American heterophyllous-leaved species; interpretation or measurement of traits closely follows methods employed by Gil-ad (1997). Bold italic type face in related species indicates a shared feather with *V. calciola.*

Trait	*V. calcicola*	*V. egglestonii*	*V. septemloba*	*V. nuevo-leonensis*	*V. triloba*
Rhizome	**short and erect (rarely elongate and oblique)**	elongate and oblique	elongate and oblique	elongate and oblique	elongate and oblique
Petiole pubescence	**glabrous**	***glabrous*** or sparsely pubescent	***glabrous***	pubescent to sparsely so	pubescent
Leaf blade lobing pattern	**many plants with unlobed leaves, others with some leaves notched or trilobate, middle segment undivided or with 1–2 lobes between it and lateral segments on each side, lateral segments undivided or shallowly lobed**	primary division 3 or 5 segments, secondary division middle w/2–4 segments, lateral undivided or with 2–3 lobes	primary division 3 segments, secondary division middle w/2 lobes, lateral undivided or with 2–4 lobes	***(sub)trilobate,*** middle and lateral segments undivided	***trilobate,*** middle segment undivided or w/1–2 lobes, lateral segments w/1–2 lobes (lower lobe undivided or bilobate)
Lobing depth	**shallowly (rarely deeply) divided**	deeply divided	deeply divided	***shallowly divided***	***shallowly or deeply divided***
Blade pubescence	**±glabrous throughout**	***glabrous throughout***	adaxial glabrous or pubescent, abaxial glabrous, margin ±ciliate	strigose throughout	sparsely pubescent throughout
Sepal shape	**broadly ovate-lanceolate to ovate, (rarely lanceolate)**	lanceolate to ***ovate-lanceolate***	lanceolate	***ovate-lanceolate to ovate***	[shape not described]
Sepal apex	**obtuse to rounded (rarely acute)**	acute to ***rounded***	acute	acute	***obtuse***
Sepal margin	**eciliate**	***eciliate*** or sparsely ciliate	***eciliate***	ciliate	irregularly ciliate
Auricle length (mm)	**0.3–0.5**	0.7–1.5	0.2–2	0.5–1.5	0.5–0.8
Interior corolla color	**whitish to violet w/white center**	violet (#83B/C) w/white center	violet (#83B) w/white center	pale violet (#86D) or violet-blue (#90D) w/white patches on lower ⅓ of each petal	violet (#83B) to purple-violet (#82A) w/white center bordered blue
Spurred petal beard	**absent**	sparse	dense	***absent***	***absent***
Lateral petal beard	**sparse**	dense	dense	***sparse***	dense
Lateral petal trichome shape	**expanded to strongly clavate near apex, the broadest cucullate**	cylindrical or often ***expanded or slightly clavate near apex***	cylindrical	cylindrical	cylindrical
Trichome width (µm)	**42–64**	ca. 100–110	70–80	***60–80***	ca. 90–100
Trichome micromorphology	**visible layer of folds 1, folds below apex curved or twisted, densely packed and overlapping (infrequently linear and somewhat separated)**	***visible layer of folds 1,*** folds below apex ***linear, twisted*** or convoluted, ***densely packed and overlapping***	***visible layer of folds 1,*** folds below apex ***linear or curved, densely packed***	***visible layer of folds 1,*** folds below apex ***linear, densely packed to widely spaced***	visible layer of folds 2, folds below apex ***linear*** or convoluted, ***upper widely spaced, lower densely packed***

Table 1. *Continued*

Trait	*V. calcicola*	*V. egglestonii*	*V. septemloba*	*V. nuevo-leonensis*	*V. triloba*
Cleistogamous peduncle final orientation	**declining, arching or erect**	prostrate	***erect***	prostrate, ***occasionally ascending***	prostrate
Cleistogamous capsule color in life	**yellow-green**	***yellow-green***	***yellow-green***	yellow-green to green, sparsely spotted & dotted w/grayed purple	yellow-green to green w/red-purple blotches & spots
Seed length (mm)	**1.50–1.75**	1.8–2.8	2.0–2.3	2.1–2.7	***1.7–2.0***
Seed width (mm)	**1.05–1.25**	1.3–1.7	***1.1–1.6***	1.2–1.7	***1.2–1.5***
Seed color	**background yellow brown (#74) to yellowish olive-brown (#87) with darker brown patches**	btw deep brown (#56) & dark brown (#59)	brown-black (darker than #65), luster shining	deep yellowish brown (#75), comprised of ***brownish black patches*** on moderate to dark orange yellow background	dark orange-yellow (#72)
Seed coat primary sculpture	**cells superficially tetra-, penta- or hexagonal, isodiametric or elongated, cell boundary furrowed, outer periclinal walls unevenly smooth**	***cells superficially pentagonal,*** isodiametric or slightly elongated, cell boundary slightly furrowed, outer periclinal walls unevenly smooth	cells superficially ***tetra-, or pentagonal isodiametric or elongated, cell boundary widely furrowed, outer periclinal walls unevenly smooth*** or finely & irregularly folded	none	none
Seed coat secondary sculpture	**narrowly oblong, pentagonal or rounded, ring-like structures of *spaced, parallel segments***	rosette-like circular plates	large elliptical or ***rounded, structures of spaced, parallel segments***	superficially foveate verrucate structures, with striated or semi-terete folds	aggregates of porous plates, occasionally folded along their margins

clavate or knob-shaped cucullate lateral petal trichomes set the new violet apart from all other lobed-leaved violets. Its sparse lateral petal beards, broader cucullate lateral petal trichomes, seeds with paler ground color and numerous darker patches, and restriction to limestone substrate are highly unusual features in the subsection; it shares sparse lateral petal beards with *V. nuevo-leonensis*, broader cucullate trichomes with *V. cucullata*, mottled seeds with *V. nuevo-leonensis*, and its confinement to limestone with *V. egglestonii*. Following Gil-ad's (1997) key to flowering plants, unlobed-leaved specimens of *Viola calcicola* will key easily to *V. cucullata*, whereas plants with lobed or divided blades will key to *V. triloba* (if one ignores the sparse beards on the lateral petals of the new species). In the Gil-ad key to cleistogamous plants, specimens of *V. calcicola* with unlobed leaf blades will key easily to *V. nephrophylla* if one ignores seed color (comparatively lighter than *V. nephrophylla* in the new species), whereas plants with lobed or divided leaf blades will key generally to *V. septemloba* if the seed color is ignored.

Lateral petal trichomes have the distinctly to strongly clavate shape of *V. cucullata* although they are much smaller than that species and scarcely overlap with *V. nuevo-leonensis* in width. The technical details of the cuticular folds generally match those of *V. septemloba*, but the folds are not as densely packed, and the fine structure of the folds (Fig. 4C–E) does not match any orthospecies or hybrid characterized by Gil-ad. Primary and secondary structures on the seed coat of *V. calcicola* share many details with *V. septemloba* and few with other species. Once again, subtle differences are obvious between the two species, with the ring-like secondary structures in the former having essentially symmetrical and parallel outlines rather than "tear-drop" or pyriform asymmetrical outlines seen in *V. septemloba*. Additionally, the central region within each of the ring-like structures of *V. calcicola* is generally uniformly depressed throughout rather than gradually diminishing in elevation from edge to center as in the structures of *V. septemloba*. Overall, macromorphological traits and preference for limestone ally *V. calcicola* most closely to *V. egglestonii*, whereas micromorphological features of petal trichomes and seeds suggest a close relationship to *V. septemloba* in many details while also highlighting unusual features in the Guadalupe violet.

Short vertical rhizomes in the blue-flowered Guadalupe Mountain violet may be largely genetically fixed but occasionally environmentally influenced, given that one plant growing mostly in deeper soils next to rock exposures has been found with an ascending, elongate rhizome typical of other members of the subsection. The habit of "sporadic heterophylly," in which most Guadalupe Mountain plants within a given population are completely unlobed whereas others produce mid-season leaves with notched or shallowly lobed (rarely deeply dissected) blades, is novel among North American violets. Populations of other heterophyllous-leaved violet species are typically comprised of plants that virtually all produce lobed or dissected blades during mid- or late anthesis and into early fruit. Plants of the new species with variously unlobed or divided leaves are otherwise identical in every other feature and are intermingled throughout a given site.

A de novo or recent hybrid origin for the violet under consideration is untenable, given that no other heterophyllous-leaved species inhabit the south-central U.S. within hundreds of kilometers of the region in question. Two other, strictly unlobed-leaved members of the subsection, *Viola missouriensis* and *V. nephrophylla*, have been recorded in nearby counties, although neither approaches the Guadalupe violet in any but a few disparate traits. The available macromorphological and micromorphological evidence supports recognition of the acaulescent blue violet in the Guadalupe Mountains as a divergent new orthospecies with an unusual restriction to limestone substrates. Characteristics and their measurements presented below follow Gil-ad (1997), and are organized generally to allow direct comparison with his descriptions of accepted orthospecies.

TAXONOMY

Viola calcicola R.A. McCauley & H.E. Ballard, sp. nov. (**Figs. 1–3**). TYPE: U.S.A. TEXAS. CULBERSON CO.: Smith Canyon, above Frijole, E of Guadalupe Mountains, 1800 m, abundant about spring, in crevices of limestone rocks, flowers nearly white, the lower petal with prominent blue lines, 3 May 1947 (fl, fr), *R. McVaugh 8149* (HOLOTYPE: TEX!; ISOTYPES: MICH, TEX!).

Acaulescent, heterophyllous, perennial herb in crevices of limestone, 3–9(–14) cm tall; rhizome vertical and praemorse, rarely oblique and somewhat elongated, typically to 2.5 cm long, 5–7 mm diam., bearing stout fi-

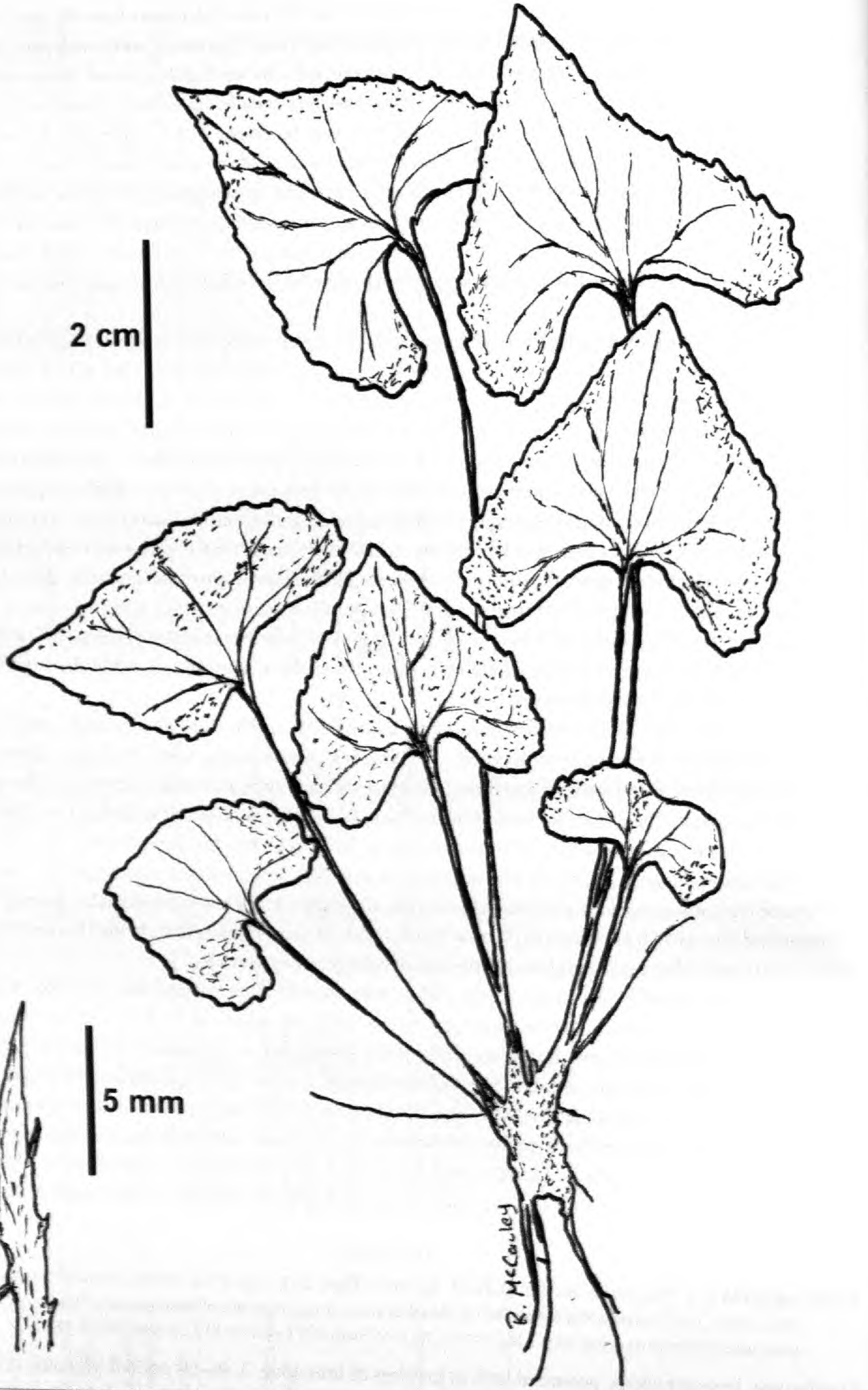


Fig. 1. *Viola calcicola* sp. nov. **A.** Habit. **B.** Stipule. Drawn from *R.A. McCauley 649* (FLD) and the holotype *R. McVaugh 8149* (TEX).

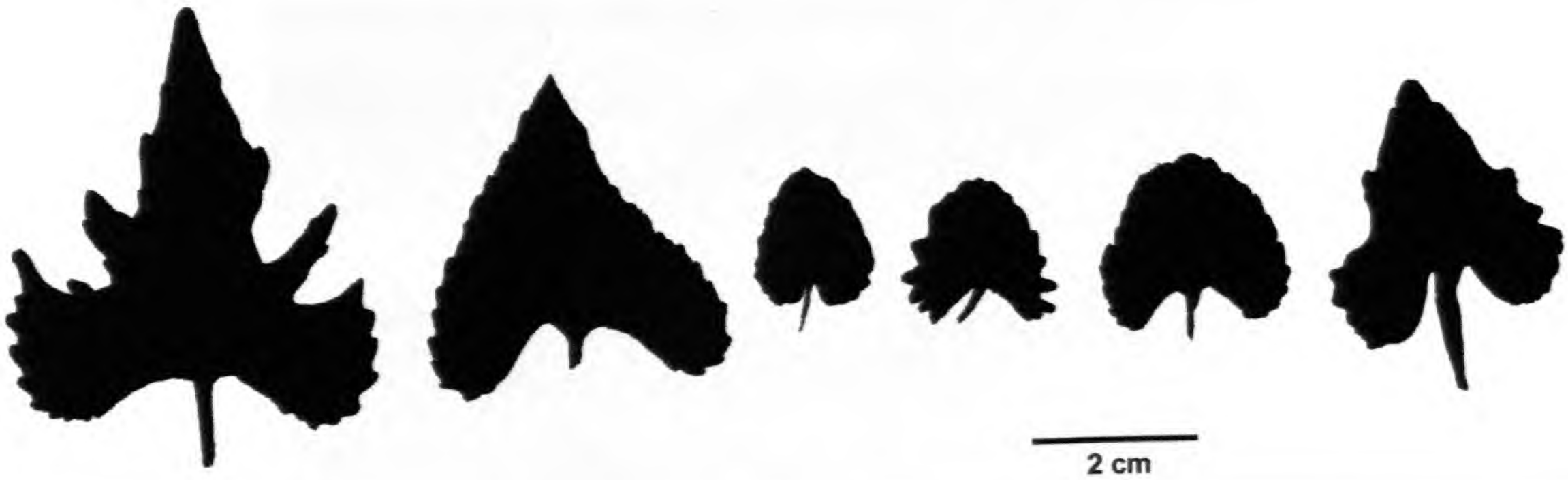


FIG. 2. Variation in leaf blade morphology in *Viola calcicola* sp. nov.

brous roots to 1 mm diam. Leaves all unlobed or with some leaves shallowly (rarely deeply) trilobate; stipules scarious to semi-herbaceous, pale or often flushed and streaked with purple, free, narrowly triangular to linear-lanceolate, 6–10 mm long, apex acuminate, margins irregularly to remotely glandular-fimbriate, eciliate; petioles on largest leaves 3–7(–9.5) cm long, green, glabrous; blades cordate or triangular-cordate to deltoid, deeply to shallowly cordate at base, margins rounded-serrate most of their length but low-serrate to subentire near apex, apex sharply acute to acuminate (larger blades) or obtuse to broadly rounded (smaller blades), medium green to darker blue-green (or drying gray-green) sometimes lightly to moderately flushed with purple abaxially, 1–3(–4.5) cm long and 0.8–3(–4.5) cm wide, largest blades at chasmogamous anthesis with length:width ratio 1.2–1.6, apical angle 31–60(–86)°, all blades either unlobed, narrowly ovate, deeply cordate at base, the larger narrowly acute to subacuminate at apex, or the larger blades on some plants notched or weakly to moderately (rarely deeply) trilobate, the middle primary division with the terminal lobe triangular to broadly oblong-ovate, broadly obtuse to (more commonly) narrowly and sharply acute at apex (rarely narrowly linear-lanceolate in the most deeply dissected blades), bearing 1–2 slender lanceolate to oblong lobes on each side near the base between the middle and lateral primary divisions, the lateral divisions obtriangular and incised or shallowly lobed (rarely deeply divided), margins remotely to uniformly serrate but less pronouncedly so nearest the apex, glabrous throughout or with occasional hairs at the base of serrations. Chasmogamous flowers on glabrous peduncles generally borne at or slightly to well above the leaf blades, peduncles elongating in fruit, 3–6(–11) cm long, green and sometimes flushed or finely dotted with purple, two bractlets inserted at variable positions on peduncle, proximal or remote, 2–3 mm long, lanceolate, green, acute at apex, margins scarious, entire, eciliate; sepals variable, ovate to broadly ovate-lanceolate in some plants, lanceolate in others, distinctly 3-veined, the midvein often pronounced and elevated near the auricles, green or flushed to suffused with purple, the lowest 3–5 mm long and 1–2 mm wide, sepal length:capsule length ratio ca. 0.6, glabrous adaxially, margins scarious and eciliate, apex commonly obtuse to broadly rounded (rarely more or less sharply acute); auricles 0.3–0.5 mm long, quadrate to broadly rounded or subtruncate, glabrous; spur 1.0–1.5 mm long; corolla 0.8–1.5 cm long, petals on different plants varying from nearly white (faintly flushed with violet) to medium purple, lateral petals having few inconspicuous purple veins, spurred petal with prominent and extensive nectar guides, lateral and upper petals narrowly obovate, spurred petal obovate with long-tapering base, 10–13(–15) mm long including spur, 3–5 mm wide, broadly obtuse to rounded at apex; spurred and upper petals glabrous within, lower lateral petal beard sparse with few to several trichomes of variable length, medial on interior surface, trichomes noticeably expanded to (more commonly) clavate or knob-shaped distally, the broadest rounded and cucullate at apex, 42–64 µm wide, with 1 layer of visible cuticular folds, folds below the apex commonly curved or twisted and densely packed, less often linear and somewhat separated, overlapping; stamens 2–2.5 mm long; style ca. 2 mm long, apex expanded into two prominent wing-like appendages, terminating in an erect stigmatic surface. Chasmogamous capsules ellipsoid, green in life (straw-

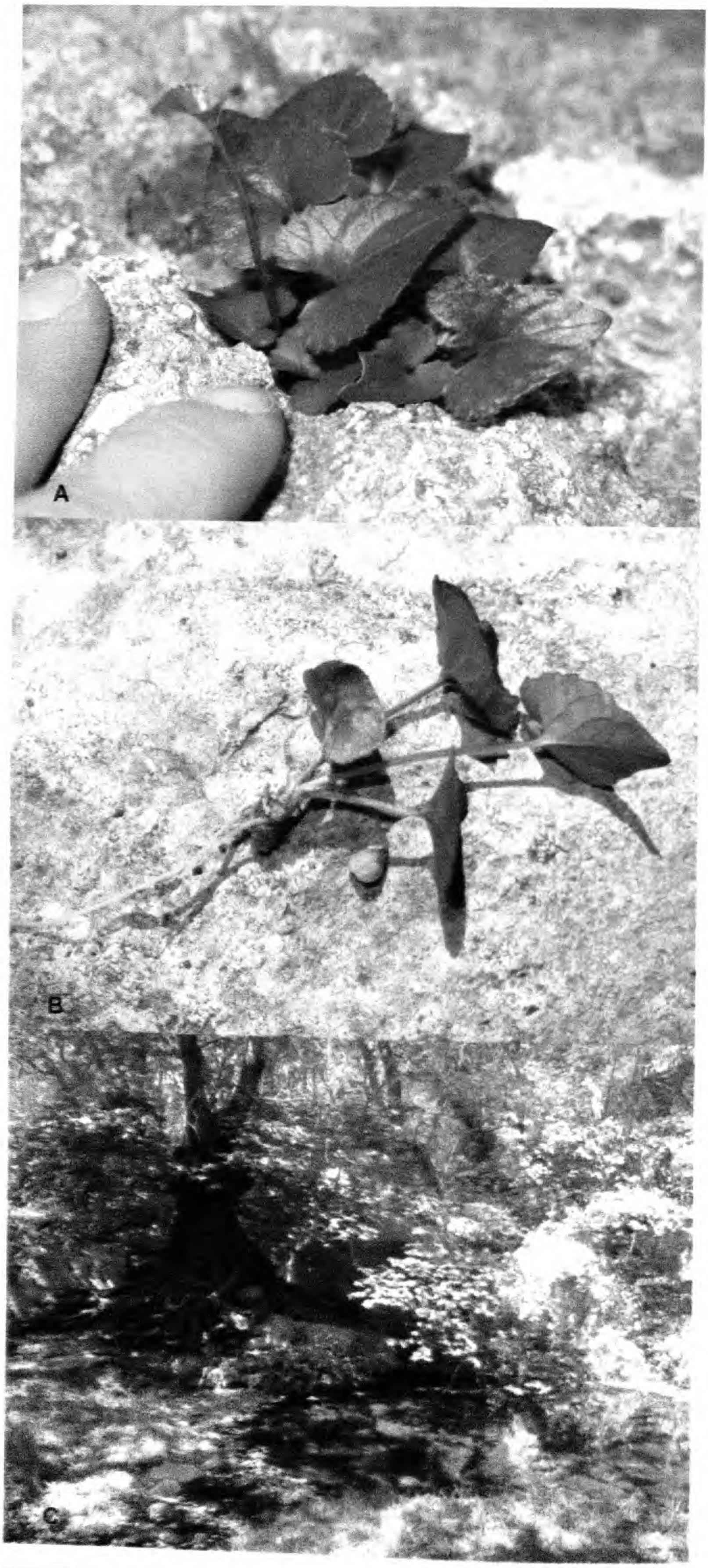


Fig. 3. *Viola calcicola* sp. nov. **A.** Photo of typical plant at type locality. **B.** Plant showing short erect rhizome and the subglobose capsule. **C.** Type locality, Smith Springs, Guadalupe Mts., May 2011.

colored when dry), sometimes finely spotted with red-purple, smooth, glabrous, (6.5–)7–9 mm long. Cleistogamous peduncles erect or arching to declining, distinctly shorter than the leaves, slender, glabrous, green, sometimes flushed or finely spotted with red-purple. Cleistogamous flower buds to 3 mm long; capsules broadly obovoid to subglobose, green in life (straw-colored when dry), smooth, glabrous, 4.5–6 mm long. Seeds from chasmogamous capsules yellow-brown (ISCC-NBS #74) with numerous slightly darkened patches, broadly obovoid, ca. 1.75 mm long, 1.25 mm wide, with a small lateral caruncle 0.30–0.5 mm long extending ⅓–⅖ the length of the seed from the funiculus; seeds from cleistogamous capsules slightly narrower and paler than chasmogamous ones, yellowish olive-brown (ISCC-NBS #87) with somewhat more contrasting darker patches giving a conspicuous mottled appearance, particularly toward the basal end, obovoid, 1.50–1.75 mm long, 1.05–1.15 mm wide, the caruncle identical to that in chasmogamous seeds. Seeds of both types under magnification displaying primary coat structure with cells superficially tetra-, penta- or hexagonal, isodiametric or elongated, the cell boundary furrowed, outer periclinal walls unevenly smooth; secondary coat structure represented by symmetrically narrowly oblong, pentagonal or rounded, ring-like structures of spaced parallel segments, the "basin" within the ring-like structures more or less uniform in elevation and mostly depressed well below the top of the structures.

Distribution and Habitat.—*Viola calcicola* occurs in scattered locations principally along the eastern flank of the Guadalupe Mountains and occasionally in the upper reaches of the larger mountain canyons. It is confined to cracks of Permian Age limestone in sheltered canyons and springs. The species is commonly found beneath an overstory association of *Acer grandidentatum* Nutt., *Arbutus xalapensis* Kunth, and *Quercus muehlenbergii* Engelm. At the type locality *V. calcicola*, while common, is highly localized to rocks in close proximity to water (e.g., rocky stream terraces or canyon walls flanking streams). The geographic distribution of the species is hundreds of kilometers distant from the nearest population of other North American heterophyllous-leaved species.

Phenology.—Blooming April to May. Fruits present May to October.

Etymology.—*Viola calcicola* is named in recognition of its obligate limestone substrate.

Taxonomic distinctions and affinities.—Other currently recognized heterophyllous-leaved orthospecies in subsection *Boreali-Americanae* are *Viola egglestonii* Pollard, found in limestone cedar glades of the east-central U.S.; *V. septemloba* Leconte, located in sandy open pine savannas in the southeastern U.S.; *V. nuevo-leonensis* W. Becker of sandy open oak-pine forests in northeastern Mexico; and *V. triloba* Schwein., found in sandy loam or clay soils in dry-mesic forests of the eastern U.S. and Canada (Gil-ad 1997). The new violet shares a restriction to limestone substrate with *V. egglestonii*, although the local floras of the two violets are dramatically different. *Viola calcicola* resembles *V. egglestonii* and *V. septemloba* in its glabrous foliage and eciliate sepals but diverges in its peculiar sporadically heterophyllous nature. However, blades on lobed-leaved plants are similar to those of *V. triloba* var. *triloba* and *V. nuevo-leonensis* as they are usually shallowly divided, with the sinuses of the lobes reaching less than halfway to the petiole summit, and the terminal lobe triangular or oblong-ovate. In *V. calcicola* occasional plants with deeply divided leaf blades closely resemble typical *V. egglestonii*. Corolla color in plants of certain sites often varies from nearly white to medium violet, and this appears to be at least partly related to topographic position (for instance, plants with moderately purple or bluish-purple corollas are generally found at or near the bottom of a canyon or escarpment, while plants with nearly white corollas grow principally in exposed microsites at or near the top of the canyon). Its sparse and localized lateral petal beard is similar to that of *V. nuevo-leonensis* and unlike other North American members of the subsection. Specimens with unlobed leaves have been misidentified frequently as *V. missouriensis*, whereas plants with conspicuously lobed leaves have been misidentified most often as *Viola* (×) *viarum*. A misidentification of specimens assigned to the latter may represent the basis for the disjunct county record of that taxon in the BONAP distribution map. The Guadalupe violet shares most of its micromorphological features in petal trichomes and seed coat with *V. septemloba*.

PARATYPES: **U.S.A. NEW MEXICO. Eddy Co.:** 38 mi SW of Carlsbad, BLM Lonesome Ridge ACEC, perennial, growing in narrow cracks in limestone, N-facing cliffs, 5–15 ft above canyon bottom, T26S R22E Sec 19 N ½ of SE ¼, 5040 ft, 29 Mar 1989 (fl), *W.W. Dunmire 1091* (UNM); Guadalupe Mts., In tiny cracks in solid limestone, 7 Apr 1937 (fl), *L.N. Goodding 2323* (NMC); Guadalupe Mts., Rocky cliffs around springs,

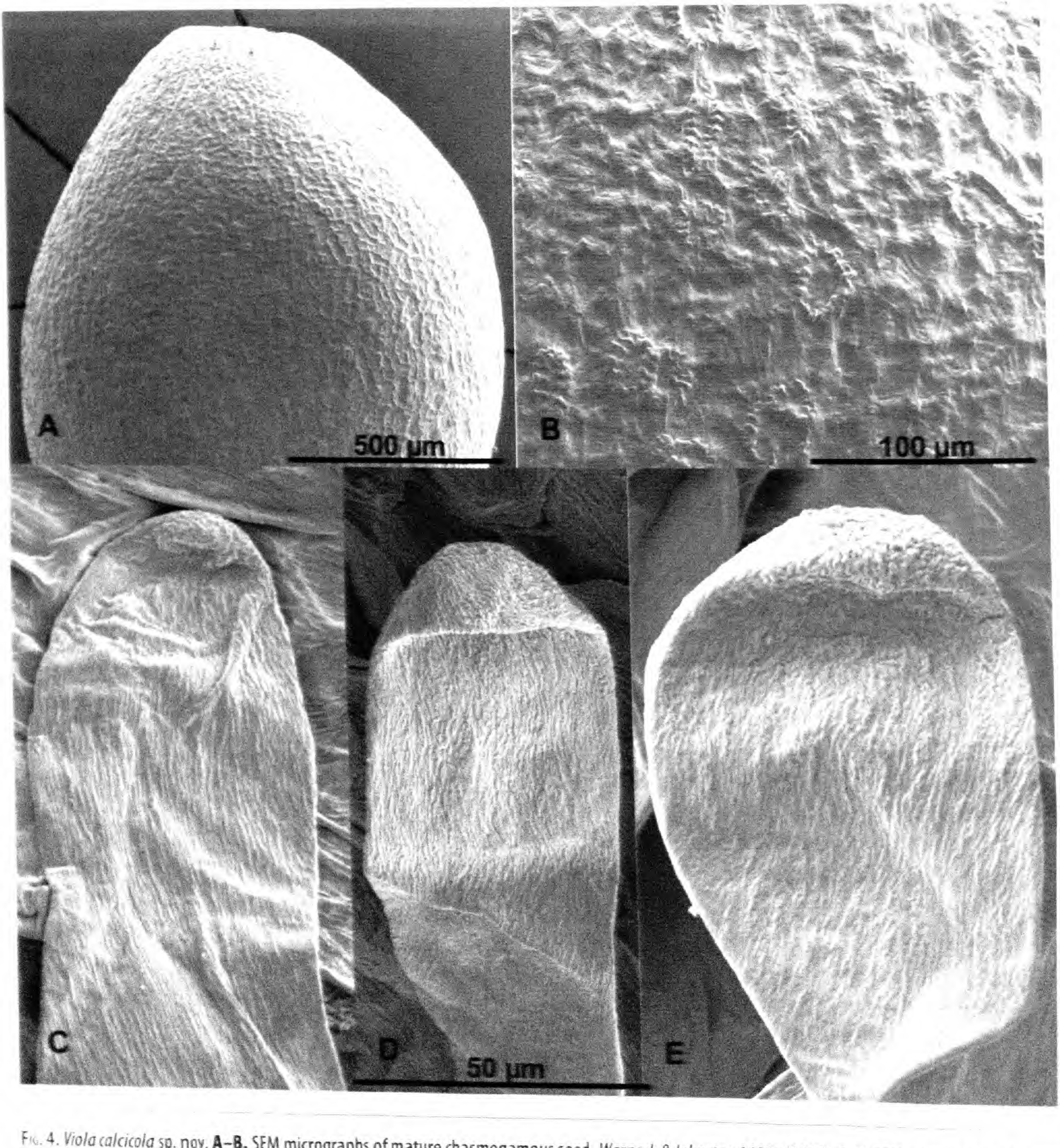


Fig. 4. *Viola calcicola* sp. nov. **A–B.** SEM micrographs of mature chasmogamous seed, *Warnock & Johnston 16536* (SRSC). **C–E.** SEM micrographs of lower lateral petal trichomes, *Warnock & McVaugh 5418* (SRSC).

27 Jun 1942 (fr), *Hershey 2639* (NMC). Guadalupe Mountains, Big Canyon, old ranch tract 2 hrs drive from Carlsbad, frequent in cracks of limestone losing corollas and going into full fruit, mostly unlobed leaf blades but occasional plants with coarsely toothed or pedately lobed blades, 29 Apr 1995 (fl, fr), *P. Knight, H.E. Ballard, P. Meloche, T. Lowrey, B. Sivinsky, L. Paul, M. Parker s.n.* (BHO, UNM); mouth of Black Canyon on E side of Guadalupe Mts., ca 30 mi S of Carlsbad, on limestone, 5000 ft, 26 Mar 1982 (fl), *P.J. Knight 1822* (UNM); on limestone, mouth of Black Canyon on E side of Guadalupe Mts., ca 30 mi S of Carlsbad, 24 May 1982 (fl), *P.J. Knight 1981* (UNM); Big Canyon just N of Black Canyon, on E side of Guadalupe Mts. ca 30 mi S of Carlsbad, on limestone, 5000 ft, 24 May 1982 (fl, fr), *P.J. Knight 1983* (NY, UNM); collected in Big Canyon of the Guadalupe Mountains, T26S R21E Sec 24 NE¼ of the SE ¼, 14 Apr 1987, (fl), *Knight and Fletcher 3419* (UNM). **Otero Co.:** N. McKittrick Canyon, At first crossing of Texas-New Mexico boundary, on the New Mexico side, Collected in gravels and boulders of stream bottom, In Riparian type habitat and below protected cliffs, Big tooth maple, Ponderosa Pine, Madrone, Hop-Horn beam, *Q. muehlenbergia* [sic!], 18 Oct 1973 (fl, fr), *T. F. Patterson 500–549 501* (LL). **TEXAS. Culberson Co.:** McKittrick Canyon, Riparian litter in limestone gravels, 5400 ft, 27 Apr 2002, (fr), *Blaxland s.n.* (GUMO); McKittrick Canyon, confluence of North & Middle canyons, Riparian litter in limestone gravels, 5680 ft, 27 Apr 2002, (fl), *Blaxland s.n.* (GUMO); North McKittrick canyon near state line, Riparian leaf litter in

limestone gravels, 5520 ft, 27 Apr 2002, *Blaxland s.n.* (GUMO); Bear Canyon, Pocket depression in shaded limestone boulders, hardwood overstory, 6720 ft, 28 Apr 2002, (fl), *Blaxland s.n.* (GUMO); North McKittrick Canyon, 28 Apr 1975, (fl), *J.K. & T.B. s.n.* (GUMO); Guadalupe Mts., Guadalupe Mountains National Park, Smith Spring, common in small cracks of limestone, 1829 m, 10 May 2011, *R.A. McCauley 649* (FLD); North McKittrick Canyon, GMNP, fairly common on limestone boulders of the inner canyons of GMNP, according to collector of this specimen, Brent Wauer, 15 Apr 1988 (fl), *A.M. Powell 5496* (SRSC); frequent in rock crevices along Smith Spring, Guadalupe Mts., 6000 ft, 10 Jul 1949 (fr), *B.L. Turner 1249* (SRSC); frequent in damp crevices and boulders of Smith Canyon, limestone soil, Guadalupe Mountains, 6000 ft, 15 Sep 1948, (fr), *B.L. Turner and B. H. Warnock 93* (SRSC); infrequent in crevices of limestone boulders in Upper Pine Spring Canyon, Guadalupe Canyon, 7000 ft, 3 May 1947 (fl), *B.H. Warnock 5418* (SRSC); fruiting, limestone bluffs above Hunter Lodge in south McKittrick Canyon, Guadalupe Mountains, 5500 ft, 31 Aug 1950 (fr), *B.H. Warnock 9512* (SRSC); infrequent perennial, limestone soil, at lodge in South McKittrick canyon, Guadalupe Mountains, J.C. Hunter ranch, 5800 ft, 20 Oct 1957, (fr), *B.H. Warnock 15952* (SRSC); sparse perennial, South McKittrick Canyon, Guadalupe Mts., limestone soil, 6200 ft, 30 April 1961 (fl, fr), *B.H. Warnock 18234* (SRSC); rare perennial, limestone soil in South McKittrick Canyon above Hunter's Lodge, Guadalupe Mountains, 6800 ft, 27 May 1968, (fr), *B.H. Warnock 23180* (SRSC); infrequent perennial in mid South McKittrick Canyon, Guadalupe Mountains National Park, 6500 ft., 25 Sep 1971 (fr), *B.H. Warnock 23336* (SRSC); infrequent perennial, flowers lavender, limestone soil, south McKittrick Canyon of Guadalupe Mountains, 6500 ft, 18 May 1958 (fl), *B.H. Warnock and M.C. Johnston 16479* (SRSC); infrequent perennial, limestone soil, lower south McKittrick Canyon, Guadalupe Mountains, 6000 ft, 18 May 1958 (fr), *B.H. Warnock and M.C. Johnston 16536* (SRSC); infrequent perennial, lavender flowers, in lower South McKittrick Canyon, Guadalupe Mountains, 6000 ft., 18 May 1958 (fl), *B.H. Warnock and M.C. Johnston 16556* (SRSC); infrequent perennial herb, Smith Spring, Guadalupe Mts. National Park, 26 July 1971 (fr), *T. Weston 147* (SRSC).

DISCUSSION

Recognition of *V. calcicola* adds a second endemic *Viola* to the Guadalupe Mountain flora, and the first heterophyllous-leaved member of the *Boreali-Americanae* group to the western U.S. The yellow-flowered *V. guadalupensis* Powell and Wauer of sect. *Chamaemelanium* also occurs in limestone along the eastern flank of Frijole Ridge and is known from approximately 4 reported populations along the eastern escarpment of the mountains (Powell & Wauer 1990; Mullet et al. 2008; Marcussen et al. 2011; F. Armstrong, pers. comm.). Anomalous specimens of a third violet, referred to by others as *Viola purpurea* Kellogg, represent a different yellow-flowered species of Sect. *Chamaemelanium* that has been rarely collected in upland areas of the Davis Mountains and in the Texas portion of the Guadalupes. Specimens assigned to this latter violet do not closely match described taxa in subsect *Purpureae* and might represent yet another new taxon. Further investigation would shed light on the status of this third *Viola*, which is disjunct by more than 500 km from the next nearest populations of the *Purpureae* to the west in Arizona.

The origin and evolutionary relationships of *Viola calcicola* are as yet unclear, although the new species is clearly related to other heterophyllous-leaved eastern species. However, the new species diverges from these others in many vegetative and reproductive traits as well as the fine micromorphological details of petal trichomes and seed coat. It shares fewer features with the other heterophyllous-leaved species than the currently recognized species share amongst each other, suggesting long-term divergence from a common ancestor. Generally, *V. calcicola* shares the most macromorphological features and also its restriction to limestone substrate with *V. egglestonii*, but most micromorphological features with *V. septemloba*. It is unique in its short vertical rhizomes and its sporadic nature of leaf blade lobing. It shares the sparse lateral petal beards with *V. nuevo-leonensis* and generally clavate to knob-shaped cucullate trichomes of the lateral petals with eastern North American *V. cucullata*. Its unusually broad range of corolla color pigmentation, even within sites, appears to correlate with elevation or ecological exposure (or both), with plants at the bottom of escarpments or canyons producing deeply pigmented corollas and plants near or at the top producing whitish corollas. One explanation is that less pigmented (more reflective) corollas at higher topographic positions aid in reducing the deleterious effects of ultraviolet radiation on reproductive structures in more exposed, sunny microsites.

Unlobed-leaved plants of *V. calcicola* could be mistaken morphologically for *Viola missouriensis* or *V. nephrophylla*, both of which are reported from southeastern New Mexico, where they reach their southern range limit. However, the new species is easily distinguished from both by its short vertical rhizome; sparse lateral petal beards composed of generally clavate to knob-shaped, cucullate lateral petal trichomes; and yellowish brown seeds with numerous darker brown patches. Its living green cleistogamous capsule differentiates it further from *V. missouriensis* and its glabrous spurred petal distinguishes it from *V. nephrophylla*.

The inferred close relationship of *Viola calcicola* with *V. egglestonii* and its broader affinities to other central U.S. and Mexican heterophyllous-leaved species are based on available morphological traits and ecological observations. Nevertheless, *V. calcicola* diverges in many features from other heterophyllous-leaved violets and possesses a few characteristics that are highly unusual or unique in the subsection. The proposed relationship hypotheses are testable using appropriate molecular markers. The authors are currently isolating and evaluating the efficacy of potentially informative microsatellite loci as well as several nuclear and chloroplast gene regions with sufficient polymorphisms to test such hypotheses. Future genetic studies on *Viola calcicola* and its *Boreali-Americanae* kin will potentially illuminate phylogenetic relationships, biogeographic affinities, and evolutionary origins of the new Guadalupe Mountain endemic and other North American species in this taxonomically challenging but evolutionarily intriguing group of violets.

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TWO NEW SPECIES OF *ERIASTRUM* (POLEMONIACEAE) FROM CALIFORNIA

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ABSTRACT

Eriastrum ertterae D. Gowen, known only from the Lime Ridge area of Contra Costa Co., and **Eriastrum rosamondense** D. Gowen, endemic to the Rosamond Dry Lake area north of Lancaster, are described as new. Prior collections of both species have been referred to *E. hooveri* in the past, but differ in flower color, stamen size and position, as well as their distinctive geographic locations.

RESUMEN

Se describen dos nuevas especies de *Eriastrum*: **Eriastrum ertterae** D. Gowen, conocida sólo en el área de Lime Ridge en el condado de Contra Costa, y **E. rosamondense** D. Gowen, endémica del área de Rosamond Dry Lake al norte de Lancaster. Colecciones previas de ambas especies han sido referidas a *E. hooveri* en el pasado, pero difieren de esta última por el color de las flores, el tamaño y la posición de los estambres, como así también por su particular ubicación geográfica.

KEY WORDS: endemic species, *Eriastrum hooveri*, Lancaster, Lime Ridge, rare plant, Rosamond

The genus *Eriastrum*, comprising 16 species from western North America, all of which occur in California, was most recently treated by De Groot et al. (2012). The purpose of the current paper is to provide names for two of the several unnamed taxa mentioned therein, both previously identified as *E. hooveri* (Jeps.) H. Mason.

Eriastrum hooveri, with corollas 5–6 mm in length, is one of the smallest flowered members of the genus. The stamens are included and usually do not reach the corolla lobe sinus. Depending on flower size, *E. hooveri* has stamens 1–1.5 mm long, inserted slightly more than that length below the sinus. The flowers are always white. The only other species with corollas nearly as small is *E. abramsii* (Elmer) H. Mason. These two species are easily distinguished from each other by a variety of characters, including leaf and bract lobe number, the amount and location of woolly pubescence, flower color, and stamen length and position. *Eriastrum abramsii* and both of the two new species proposed in this paper have corollas that are pale blue, or have blue streaking. Although many *Eriastrum* species can be recognized by vegetative or flower size and color characters, perhaps the most important diagnostic characters involve stamen length and position (Mason 1945; Harrison 1959, 1968).

The seemingly minute stamen differences between these *Eriastrum* with small corollas, is more readily apparent than the measurements would suggest. Splitting the corollas lengthwise and observing with a microscope works well. I have also found that collecting corollas into a clear plastic sandwich bag, and placing this in a plant press until dry, is useful. This allows one to simply hold the bag up to the light and observe the arrangements of the flower parts with a hand lens.

TAXONOMIC TREATMENTS

Eriastrum ertterae D. Gowen, sp. nov. (**Fig. 1 A–E**). TYPE: U.S.A. CALIFORNIA. Contra Costa Co.: Lime Ridge Open Space, S of summit near power line area, 1 Jul 2005, *Gowen 471* (HOLOTYPE: JEPS; ISOTYPE: BRY).

Differing from *E. hooveri* by having larger corollas tinted with blue (rather than white), stamens attached lower in the tube, and anthers reaching the corolla lobe sinus or beyond (rather than included and generally not reaching the corolla sinus).

Plants erect annuals, 1.5–20(–25) cm; stems simple or branching, internodes 0.5–3 cm; herbage lightly floccose. **Leaves** light green, to 3 cm long, subulate-awn tipped, with one pair of lateral lobes or entire, lobes 2–8 mm long. **Inflorescences:** heads 1 to few, floccose, 0.5–1.0 cm long excluding tips of bracts; bracts to 1.4 cm long, exceeding heads, with 1 pair of lateral lobes. **Calyx** 4–7 mm long, densely woolly, lobes unequal, tips not obscured by trichomes. **Corolla** regular, sub-salverform, 5–7 mm long, throat plus tube 3–5 mm long, lobes appearing almost white but with pale blue tint or blue streaking, elliptic-acute, 2 mm long, 1 mm wide. **Sta-**

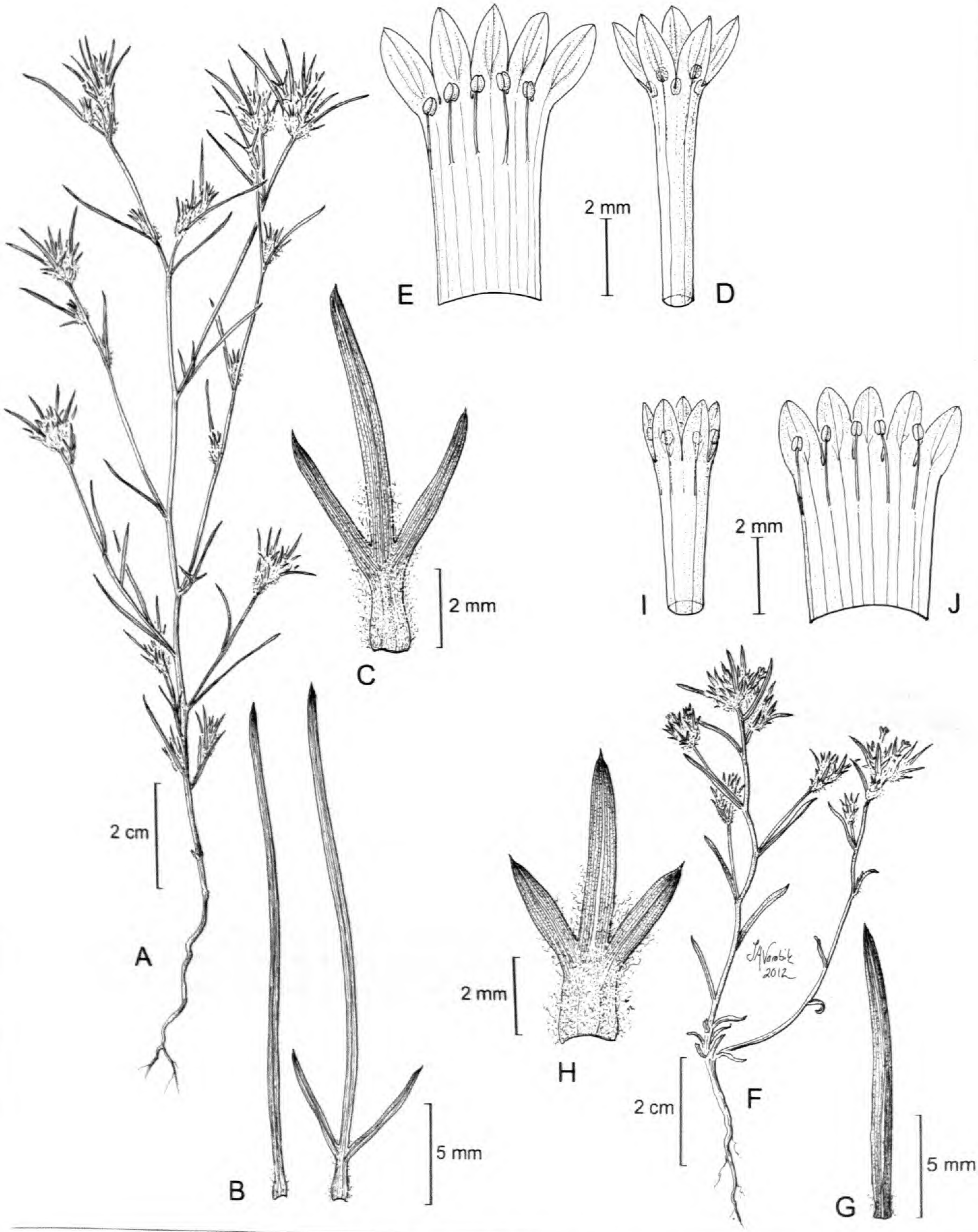


Fig. 1. (A–E). *Eriastrum ertterae*. **A.** Habit. **B.** Leaves. **C.** Bract. **D.** Corolla. **E.** Dissected corolla. (F–D). *Eriastrum rosamondense*. **F.** Habit. **G.** Leaf. **H.** Bract. **I.** Corolla. **J.** Dissected corolla.

mens 1.5–2.5 mm long; filaments 1.25–2 mm long, sinus to stamen insertion 2 mm; anthers versatile, cordate, 0.3–0.5 mm long, reaching the corolla lobe sinus and usually exserted just beyond. **Style** ca. 2.5 mm long, stigmas 0.25–0.5 mm long. **Capsule** 4 mm long, 2 mm wide, 3-loculed, each locule 2–4 seeded.

Paratypes: **U.S.A. California. Contra Costa Co.:** Lime Ridge Open Space [all collections]: in saddle SE of microwave towers on summit, 18

Oct 1998, *Ertter 16441 with Morosco* (UC); near transmission tower, 14 Jun 2003, *Gowen s.n.* (JEPS); E side of hill 724, 5 Jun 2005, *Gowen 404* (JEPS); power line area, 6 Jul 2005, *Gowen 472* (JEPS).

Distribution and habitat.—Lime Ridge Open Space, slightly northwest of Mt. Diablo, between the towns of Clayton and Walnut Creek, is the only known location for *E. ertterae*. There are three small sites where the plant grows, distant from each other by 0.2–0.7 km. It grows in fine sandy soil in openings or the edges of the chaparral. Depending on weather patterns for any given year, each site might only have several hundred to possibly a thousand plants, making *E. ertterae* a plant of obvious conservation concern.

Discussion.—Until relatively recently, *Eriastrum* was nearly unknown in Contra Costa County. There are two historic records for *E. pluriflorum* (A.A. Heller) H. Mason, one from the late 1800s, and one from 1933, but no known extant populations. There is also a historic Brandegee collection of *E. sapphirinum* (Eastw.) H. Mason, most likely with erroneous location data, that was more likely collected in southern California (Brandegee collections with erroneous locality information are, unfortunately, common). It has only been within the last two decades that *E. abramsii* was found at two locations approximately 5 and 8 km east of the summit of Mount Diablo (*Gowen 12* and *609*).

It was therefore a surprise in June 2003 to find an *Eriastrum* at Lime Ridge, about 8 km northwest of Mount Diablo, while searching for a perplexing *Navarretia* I had seen there many years before. A review of the supplement in the just-published updated flora of Mount Diablo (Ertter & Bowerman 2002) revealed that Barbara Ertter and Tony Morosco had collected dried fruiting plants (not identifiable to species) from the same locality in 1998. Unfortunately, fresh flowering material was no easier to determine, as it didn't fit well with any described species. Several years of additional fieldwork, morphological analysis, and common garden experiments have confirmed that this extremely localized entity is a distinct taxon.

Eriastrum ertterae is most similar to *E. hooveri*, but has more robust corollas (size and texture), with a pale blue tint or streaking on the lobes. The stamens are longer, and the position of the anthers relative to the corolla lobe sinus differs; *E. ertterae* has anthers placed at, or just beyond the sinus. The attachment point of the filament is almost at the mid distance of the total corolla length. By comparison, *E. hooveri* has corolla lobes that are proportionally longer to the total length of the corolla. Because the stamens are shorter and included, the anthers are placed not far beyond the mid length of the corolla. Geographically, *E. ertterae* is separated from the closest population of *E. hooveri* in the Panoche Hills of western Fresno County by approximately 160 km.

Blooming time was found to differ between *E. ertterae* and *E. hooveri*, both in the field and with plants grown under common garden conditions by the author in Oakland, California. The first flowers to appear on *E. ertterae* were almost a month later than for *E. hooveri*, which were grown using seeds collected from representative populations throughout its entire range.

Etymology.—The specific epithet honors Barbara Ertter (b. 1953), the taxon's first collector, in appreciation for the encouragement and guidance that she has given me over many years. For all the energy she has focused on the local Bay Area flora, it is only fitting to have a very local plant named in her honor.

Eriastrum rosamondense D. Gowen, sp. nov. (**Fig. 1 F–J**). TYPE: U.S.A. CALIFORNIA. Los Angeles Co.: NW of Lancaster at the SW quadrant of West Avenue D and 30th St. West, 12 May 2010, *Gowen 1110* (HOLOTYPE: JEPS; ISOTYPE: BRY).

Differing from *E. hooveri* by having corollas pale blue (rather than white), and stamens exserted almost half the corolla lobe length (rather than included). Differing from *E. diffusum* by having smaller flowers, and leaves entire (rather than leaves mostly with one pair of lateral lobes).

Plants erect to spreading annuals, 2–8(–11) cm; stem simple or branching, usually from the base, internodes to 1.5 cm; herbage and stems lightly floccose to glabrescent. **Leaves** light green, to 1.5 cm long and 1 mm wide, subulate-awn tipped, entire. **Inflorescences:** heads 1 to few, floccose, 4–7 mm long excluding tips of bracts; bracts 4–14 mm long, with 1 pair of lateral lobes 3–4 mm long, these often recurved. **Calyx** 5 mm long, densely woolly except toward the tips, lobes unequal, tips not obscured by trichomes. **Corolla** regular, sub-salverform, 5–6(–7) mm long, throat plus tube ca. 4 mm long, lobes pale blue but sometimes appearing almost white, lobes elliptic-acute with tips sometimes slightly rounded, 1.5–2(–2.5) mm long and 0.9 mm wide. **Stamens** 2–2.5 mm long; filaments ca. 2 mm long, sinus to stamen insertion 1 mm; anthers versatile, cordate, 0.25–0.5 mm long, exserted to near or slightly beyond the mid-length of the corolla lobe. **Style** ca. 3 mm long, stigmas ca. 0.3 mm long. **Capsule** ca. 4 mm long, 2 mm wide, 3-loculed, each locule 2–4 seeded.

Paratypes: **U.S.A. California. Los Angeles Co.:** Lancaster, 11 Jul 1892, *Davidson s.n.*, in part (RSA); Lancaster, May 1909, *Brandegee s.n.* (UC); border of alkali flat, Lancaster, 29 Apr 1930, *Hoffman s.n.* (CAS); Antelope Valley, W of Lancaster, N side of Avenue G, 27 Apr 1998, *Porter 11834* (CAS, RSA); Hwy. 138 (West Ave. D) W of Lancaster, NE corner of intersection with 40th St. W., 11 May 2005, *Gowen 309* (JEPS); Hwy 138 (West Ave. D) W of Lancaster, areas on both sides of the road at the intersection with 30th St. West, 21 May 2005, *Gowen 351* (JEPS); intersection of Hwy 138 (W. Ave. D) and 40th St. W. on the SW corner, 8 Jun 2005, *Gowen 412* (JEPS); 40th St. West and Avenue D, 12 May 2010, *Gowen 1111* (JEPS).

Distribution.—The presently known distribution covers only a several mile area between Rosamond and Lancaster. It is centered near the intersection of Hwy 14 and Hwy 138 (West Avenue D), near the northern border of Los Angeles County. Such a small area of occurrence for *E. rosamondense* makes this a rare plant deserving of conservation.

Discussion.—Plants now proposed as *E. rosamondense* have been known from the Lancaster area from at least 1892. A mixed collection of this plant and *E. sapphirinum*, by Davidson (RSA 469271) in that year, and a Brandegee collection in 1909 (UC 130872), are known to the author. These collections have been referred to *E. diffusum* in the past. A collection by R. Hoffman, 29 Apr 1930 (CAS 178681) has been variously attributed to *Gilia filifolia* var. *diffusa* [*E. diffusum*], annotated as "sp" by Harrison, and annotated by Hoover as *E. hooveri*. More recently, plants from near Lancaster were attributed to *E. hooveri* (Boyd & Porter 1999). All of these collections represent *E. rosamondense*. There is one known occurrence of *E. hooveri* from 7 km east of Isabella Lake, a low valley near the southern end of the Sierra Nevada (*Gowen 945*), but *E. hooveri* is otherwise not known from east of the San Joaquin Valley. It does not occur in the Mojave Desert.

The small flowers of *E. rosamondense* are easily confused with *E. hooveri*, but the pale blue flowers and exserted stamens of *E. rosamondense* distinguish the two species. More problematic is the relationship with *E. diffusum*. Structurally, *E. rosamondense* is like a miniature of *E. diffusum*, and its placement as a subspecies of that taxon was considered. However, *E. diffusum* does not occur closer than 100 km to the east, in San Bernardino County. In addition, the leaves of *E. rosamondense* are entire, whereas *E. diffusum* most often has leaves with a pair of lateral lobes.

Etymology.—The specific epithet refers to the Rosamond Dry Lake area between Lancaster and Rosamond.

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CAREX CYRTOSTACHYA (CYPERACEAE), A NEW SPECIES OF SEDGE ENDEMIC TO THE SIERRA NEVADA OF CALIFORNIA

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ABSTRACT

Carex cyrtostachya is described as a narrow endemic from the western slope of the northern Sierra Nevada of California. Details about its taxonomy, distribution, and ecology are included. *Carex cyrtostachya* is distinguished from *Carex mendocinensis* by its more flexuous distal lateral spikes with more widely spaced perigynia, longer and paler pistillate scales, and longer staminate scale awns. A key and illustrations are provided. Lectotypes are designated for *Carex cinnamomea* and *Carex mendocinensis*.

RESUMEN

Se describe **Carex cyrtostachya** como endemismo de la vertiente norte de la Sierra Nevada de California. Se incluyen detalles de su taxonomía, distribución, y ecología. *Carex cyrtostachya* se distingue de *Carex mendocinensis* por sus espigas laterales distales más flexuosas con utrículos más espaciados, escamas pistilares más largas y más pálidas, y aristas de las escamas estaminales más largas. Se aporta una clave e ilustraciones. Se designan lectotipos para *Carex cinnamomea* y *Carex mendocinensis*.

KEY WORDS: California, *Carex*, *Carex* section *Hymenochlaenae*, Cyperaceae, narrow endemic, Sierra Nevada

Several workers in the flora of the northern Sierra Nevada of California have been puzzled by a sedge resembling *Carex mendocinensis* Olney ex W. Boott, but which differs from it on the basis of inflorescence features and is disjunct from the coastal and coast range habitats of that species (Janeway 1992; Oswald & Ahart 1994; Oswald 2002; Clifton 2003, 2005; Taylor 2010). After studying the Sierran populations, we describe them here as a new species. It was first collected in 1968 by G. Ledyard Stebbins.

Carex cyrtostachya Janeway & Zika, sp. nov. (**Figs. 1, 2A, 3A-B, 4A-G, 5**) TYPE: U.S.A. CALIFORNIA. Butte Co.: Forest Road 20N03 (Mooreville Ridge Road), 2 air mi SE of Sugar Pine Point, Pinkard Creek drainage, 1075 m, 5 Aug 2011, *Zika 25715 & Wilson, Ahart, Janeway* (HOLOTYPE: WTU; ISOTYPES: BRU, CAS, CHSC, DAV, GH, JEPS, MICH, NY, OSC, RSA).

Carex cyrtostachya differs from *Carex mendocinensis* in its more flexuous distal lateral spikes with more widely spaced perigynia, longer and paler pistillate scales, and longer staminate scale awns.

Plants cespitose, with short rhizomes; roots brown, not densely felted with root hairs. Fertile culms (stems) 20–132 cm long, 0.4–2.3 mm wide, trigonous, smooth on the angles; basal sheaths scale-like, bladeless, with pale veins, scabrous-ciliate, dark purple, grading above into red-purple, red-brown, and green sheaths, the upper of these bearing blades. **Leaves** (2–)3–5, mostly on lower half of culm; sheaths 6–80(–142) mm long, tightly clasping culm, glabrous to scabrous, green, the sheath faces (opposite blade) green to whitish, often

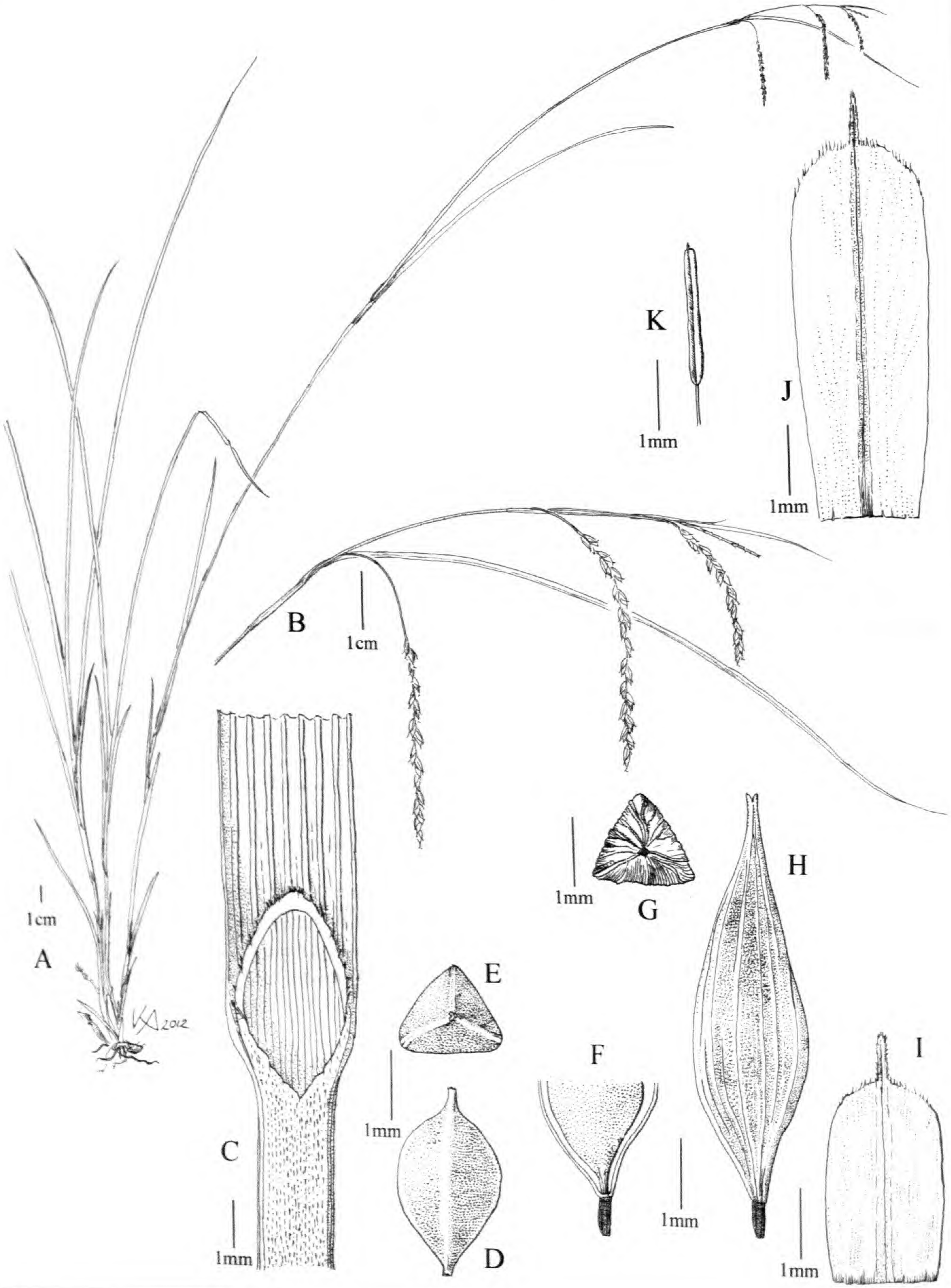


Fig. 1. *Carex cyrtostachya* (*Zika 25715*, except C, *Zika 25712*). **A.** Habit. **B.** Inflorescence showing drooping pistillate spikes and lax culm. **C.** Sheath, blade, and ligule, with culm removed. **D.** Achene, side view. **E.** Achene, top view. **F.** Perigynium partially dissected to show stipitate base of achene, above darkened perigynium stipe. **G.** Perigynium top view, triangular in cross-section. **H.** Perigynium side view, showing darkened stipitate base. **I.** Pistillate scale. **J.** Staminate scale. **K.** Stamen, showing bristle tipped anther.

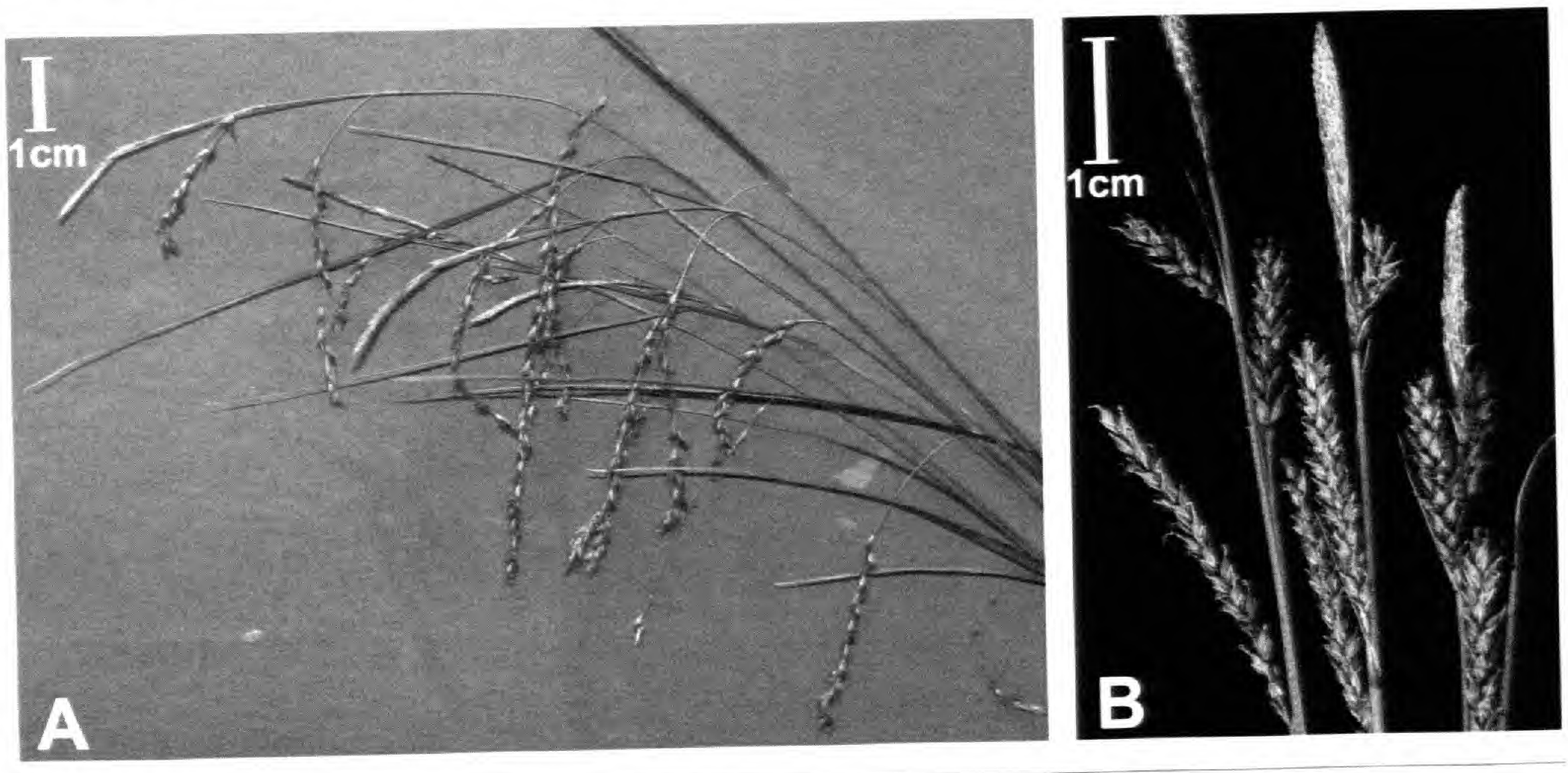


Fig. 2. Comparison of inflorescences, live plants. **A.** *Carex cyrtostachya*, showing drooping distal pistillate spikes on lax peduncles (*Zika 25715 et al.*). **B.** *Carex mendocinensis*, showing erect distal pistillate spikes on erect peduncles (*Zika 13156*).

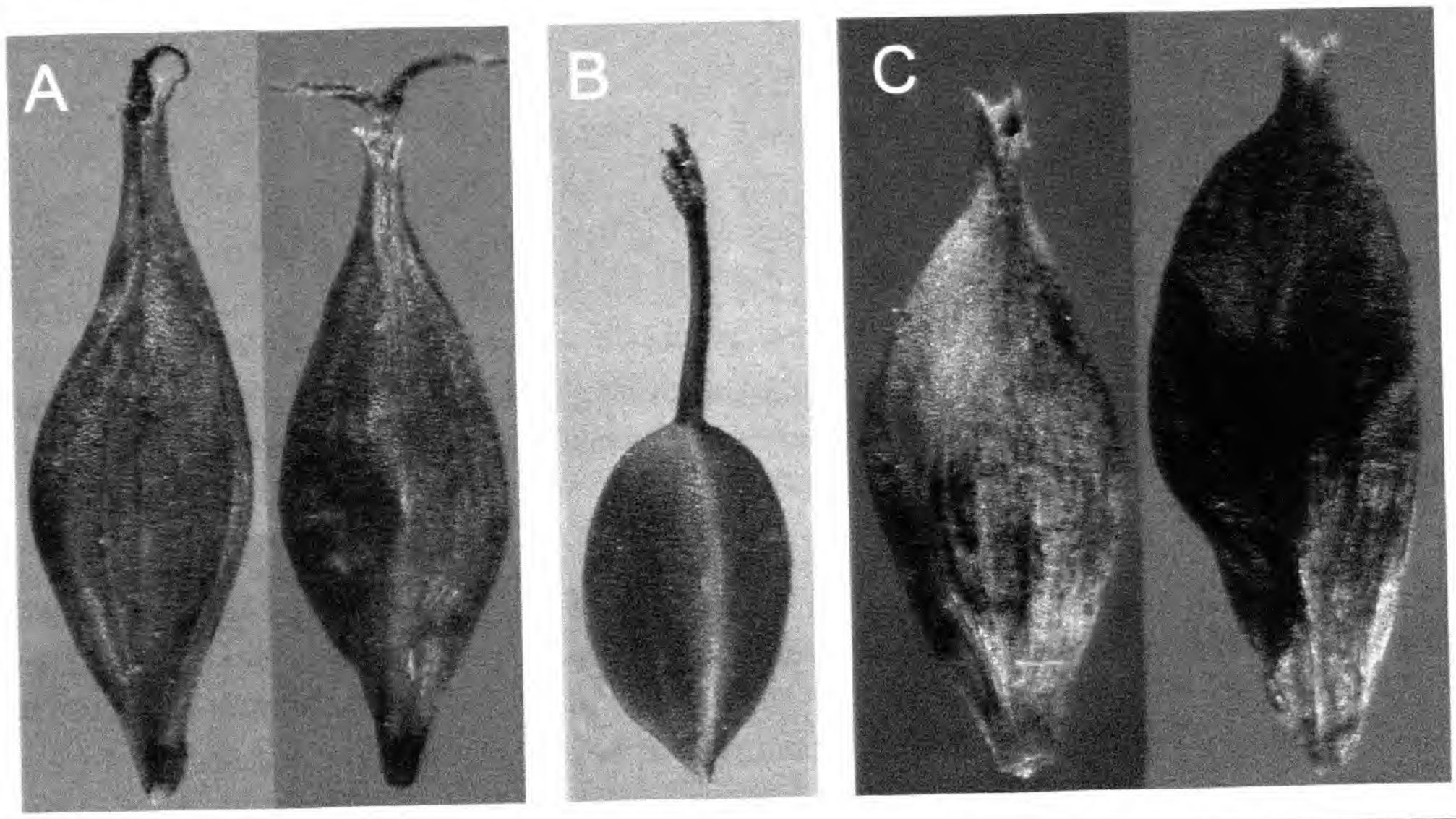


Fig. 3. Comparison of dried perigynia. **A.** *Carex cyrtostachya* perigynia, green to light brown (*Zika 25713 et al.*). **B.** *Carex cyrtostachya* achene (*Zika 25713 et al.*). **C.** *Carex mendocinensis* perigynia, green to light brown with dark purple markings (*Zika 25485*).

dotted with red or purple, glabrous or scabrous, the apex (mouth) U- or V-shaped, ciliate, fragile; ligules 1.1–12.6 mm long, longer than wide, apex acute or acuminate, occasionally rounded, ciliate; blades 0.5–42 cm long, (1.3–)1.5–4.5(–6) mm wide, flat, V- or W-shaped in cross-section, occasionally strongly scabrous on adaxial surface near ligule, otherwise smooth, with 1–3 pale prominent abaxial veins, margins scabrous distally. Vegetative shoots similar to fertile shoots; pseudoculms (overlapping leaf sheaths of vegetative shoots, see Reznicek 1986) 4–6 cm tall, with 3-6 leaves, the larger basal leaves 2.5–5.7 mm wide. Proximal inflorescence bracts with sheaths (2.5–)6–42 mm long, the blades shorter than to exceeding inflorescence, 5.5–25.5 cm long, 0.9–2.5 mm wide, glabrous or slightly ciliate, the distal bracts much reduced. **Inflorescences** 5–47 cm long, the lateral spikes pistillate, the terminal spike staminate; proximal lateral spikes on peduncles 17–171 mm

long, the portion exserted from the sheath 10–114 mm long (rarely the proximal spike branching once from the basal pistillate scale, *Janeway 9080* CHSC, *Rubtzoff 7088 & Howell* CAS); lateral spikes solitary at the nodes, arching, often drooping at maturity on flexible, smooth or slightly scabrous peduncles, the two proximal spikes separated by 2–28 cm, the distal spikes overlapping, on peduncles 5–25 mm long, rarely sessile; terminal spike erect on peduncle 5–26 mm long. **Spikes** 3–6, the lateral spikes pistillate (very rarely androgynous), cylindrical, 18–93 mm long, 2–5.7 mm thick, with (10–)14–29 perigynia attached 0.7–3.5(–6) mm apart, the terminal spike staminate, 10–64 mm long, 1.1–2.3 mm thick, rarely gynecandrous (*Rubtzoff 7088 & Howell* CAS) and the lower half staminate. **Pistillate scales** usually shorter than mature perigynia, obovate to oblong-obovate, (2.2–)3–4.8(–6.8) mm long including glabrous or ciliate awn, acute, rounded or notched at apex (apart from awn), glabrous with ciliate or erose margins distally, white-hyaline or faintly marked with red-brown, uncommonly red-spotted; awn (0–)0.5–2.2(–3.1) mm long; midrib broad, green, aging brown, with 1–3 veins, rarely with sparse bristles distally. **Staminate scales** densely overlapping, clasping at base, oblanceolate to oblong-oblanceolate, 4–6.9(–8) mm long, acute, rounded, or notched at apex, hyaline with green midvein, glabrous, the proximal scales with prominent awn 0.5–3(–5) mm long. **Anthers** 3, 1.8–3 mm long, slightly ciliate at apex (40×). **Perigynia** erect-ascending or appressed when mature, (3.2–)3.8–5.8 mm long, 1.1–1.8 mm wide, bases gradually narrowed to darker stipes 0.3–0.6 mm long; body ± flattened-trigonous, ± symmetrical in top view, 2-ribbed and finely 12–15-veined, green, aging to brown, occasionally with inconspicuous red or purple dots, membranous, glabrous, gradually tapered to beak; beak (0.5–)0.7–1.4 mm long (measured from inflection point); apical teeth obscure, 0.2–0.6 mm long, often ciliate on or between them. **Achenes** (nutlets) 1.9–2.7 mm long (not including style remnant or stipe), 1.1–1.6 mm wide, trigonous, stipitate, the distance from the base of the achene body to the base of the perigynium (0.5–)0.7–1.2 mm, achene sides ± flat to slightly concave, obovate to elliptic, ± loosely enclosed by perigynium, pale brown, papillose (40×). **Styles** withering but ± straight and persisting in the mature perigynia, where easily broken; stigmas 3.

Achene surface micromorphology.—We gathered ripe achene specimens in 2011 from two accessions of *Carex cyrtostachya* and three accessions of *C. mendocinensis*. Following Waterway (1990a), we removed the waxy cuticle and the outer periclinal walls of the epidermal cells with a 6-hour treatment in deionized water in a Branson Model 1210 Bransonic cleaner, exposing the papillae (formed by conical silica bodies) on the inner periclinal walls of the epidermal cells. Achenes were next rinsed three times in deionized water, air dried overnight in a desiccator, then mounted and sputter coated with gold for three minutes (10 mA, at 65 mTorr) with a Technics Hummer V. Digital scans were captured with a JEOL JSM-840A SEM. Because the shape and number of papillae varied the most near the angles of the achenes, our scans were all from the central portion of the achene faces.

Although we found considerable variation in the achene surfaces of *Carex cyrtostachya* and *C. mendocinensis* (Fig. 4), considerable differences in surface micromorphology between the two species were apparent. *Carex mendocinensis* tends to have many papillae (up to six) per cell (Fig. 4J, L, M). The papillae can cover a large portion of the supporting cell platform (Fig. 4M, N). The gaps between cells can be wide and intricately buttressed (Fig. 4M, N). In contrast *C. cyrtostachya* had one (or rarely two) papillae per cell (Fig. 4D, E), the papillae often occupied a smaller percentage of the supporting platform (Fig. 4C, G), and the gaps between cells tended to be narrow and without ornament (Fig. 4G). However, our sample was small, and some achene surfaces were similar for the two species (Fig. 4C, E vs. J, K). *Carex cyrtostachya* achene surfaces also resembled those of *C. hirtissima* W. Boott (Waterway 1990a, Fig. 8).

Phenology and ecology.—*Carex cyrtostachya* fruits from May through August, depending on elevation and exposure. It ranges from 600–1350 m elevation. According to herbarium labels, the colonies are found over argillite, granodiorite, and (rarely) peridotite bedrock. The sites vary from full sun to shade, in wet meadows, marshes, seasonally wet outcrops, seeps, swales, and riparian margins with saturated soil, as well as floodplain terraces on more mesic soils.

Carex cyrtostachya commonly grows in the shade of woody species such as *Acer macrophyllum* Pursh, *Alnus rhombifolia* Nutt., *Arbutus menziesii* Pursh, *Calocedrus decurrens* (Torr.) Florin, *Cornus nuttallii* Audubon ex

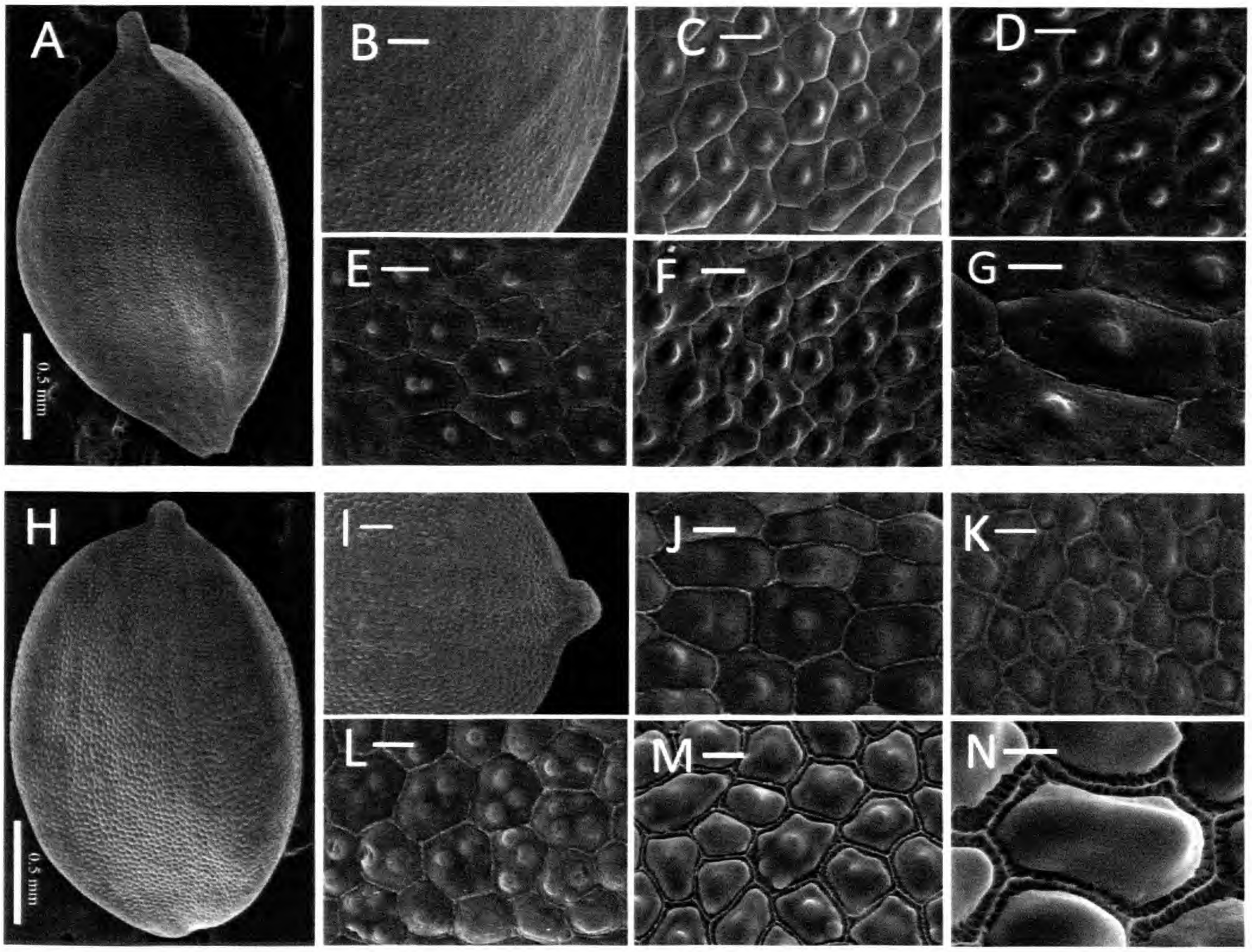


Fig. 4. SEM images of achene surfaces of *Carex cyrtostachya* and *C. mendocinensis*. **A–G:** *Carex cyrtostachya* (all Yuba Co., California, *Zika 25718*; except B–C, Butte Co., California, *Zika 25715*). **A)** Achene shape. **B)** Papillose achene surface; scale = 100 µm. **C–F)** Variation in cell surfaces, mostly one papilla per cell, occasionally two; scale = 20 µm. **G)** Detail of cell surfaces, narrow gaps between cells, broad platforms surrounding relatively small central and round-topped solitary papillae; scale = 10 µm. **H–N:** *Carex mendocinensis*; **H–J, L,** Josephine Co., Oregon, *Zika 25485*; **K,** Josephine Co., Oregon, *Zika 25488*; **M–N,** Humboldt Co., California, *Zika 25496*. **H)** Achene shape. **I)** Papillose achene surface; scale = 100 µm. **J–M)** Variation in cell surfaces, one to five papillae per cell; scale = 20 µm. **J)** Broad platforms surrounding relatively small central and round-topped solitary papillae. **M)** Narrow or obscure platforms surrounding large and coalesced central papillae. **N)** Detail of cell surfaces, broad gaps between cells, steep-sloping and relatively large acute-topped papillae; scale = 10 µm.

Torr. & A. Gray, *Corylus cornuta* Marshall, *Lithocarpus densiflorus* (Hook. & Arn.) Rehder, *Pinus contorta* Douglas ex Loudon, *P. lambertiana* Douglas, *P. ponderosa* Douglas ex Lawson & C. Lawson, *P. sabiniana* Douglas ex D. Don, *Pseudotsuga menziesii* (Mirb.) Franco, *Quercus durata* Jeps., *Rhododendron occidentale* (Torr. & A. Gray) A. Gray, *Rubus armeniacus* Focke, *R. laciniatus* Willd., and *R. leucodermis* Douglas ex Torr. & A. Gray. Herbaceous associates are diverse, corresponding to variation in soil moisture. Some typical associates are *Adenocaulon bicolor* Hook., *Agrostis pallens* Trin., *A. scabra* Willd., *Aquilegia formosa* Fisch. ex DC., *Carex amplifolia* Boott, *C. bolanderi* Olney, *C. feta* L.H. Bailey, *C. hirtissima* W. Boott, *C. laeviculmis* Meinsh., *C. lemmonii* W. Boott, *C. pachystachya* Cham. ex Steud., *C. stipata* Muhl. ex Willd., *Circaea alpina* L., *Equisetum arvense* L., *E. hyemale* L., *Fragaria vesca* L., *Galium bolanderi* A. Gray, *Geum macrophyllum* Willd., *Hieracium albiflorum* Hook., *Juncus effusus* L. subsp. *pacificus* (Fernald & Wiegand) Piper & Beattie, *J. exiguus* (Fernald & Wiegand) Lint ex Snogerup & Zika, *J. laccatus* Zika, *J. triformis* Engelm., *Linnaea borealis* L., *Luzula comosa* E. Mey. var. *laxa* Buchenau, *L. parviflora* (Ehrh.) Desv., *Mimulus moschatus* Douglas ex Lindl., *Pteridium aquilinum* (L.) Kuhn, *Rhynchospora capitellata* (Michx.) Vahl, and *Scirpus microcarpus* J. Presl & C. Presl.

Etymology.—*Carex cyrtostachya*, or arching sedge, is named for its curving or pendulous (*cyrto-*) pistillate spikes (*-stachya*).

Distribution.—The range of *Carex cyrtostachya* is limited to the northern Sierra Nevada foothills and northern high Sierra Nevada geographic subdivisions (Baldwin et al. 2012), from El Dorado County north to Yuba and Butte counties, California (Fig. 5). Populations of *C. cyrtostachya* are discontinuous within its range on the western slopes of the Sierra Nevada, with one cluster of populations in southeastern Butte County and adjacent Yuba County, and the other in El Dorado County. Only 13 populations have been documented, most of them quite small, within an area of 120 × 30 km. No populations have been found in the intervening Placer, Nevada, or Sierra counties. Arching sedge is thus a narrow endemic, restricted to just three counties in California. There are 12 other endemic *Carex* species in California (Mastrogiuseppe 1993, Zika 2012, Zika et al. 2012), as well as additional endemic members of the Cyperaceae, such as the recently described *Eleocharis torticulmis* S.G. Sm., restricted to a small area in the northern high Sierra Nevada of Plumas County (Smith 2001).

Conservation.—Most *Carex cyrtostachya* populations are small, difficult to locate, and potentially threatened by logging and invasive *Rubus*. The species should receive some conservation attention. More inventory is needed and systematic census data are lacking, but based on our initial field surveys and observations, and the herbarium records, there may be fewer than 20 populations and 2000 plants in total. A few populations are on land managed by the US Forest Service, in the Plumas and El Dorado National Forests, but other locales are at low elevations on private land and susceptible to development or hydrological changes.

Additional specimens examined: **U.S.A. California. Butte Co.:** Bean Creek bridge on Bean Creek Road, 609 m, 29 Jun 1988, *Ahart 6108* (CAS, CHSC); marshy meadow at upper reach of Brush Creek, 953 m, 2 Jul 1988, *Janeway 2955* (CHSC, WS); small lake 1 mi S of Brush Creek, 997 m, 14 May 1990, *Oswald 4208* (CHSC, WS); 0.25 miles W of Lost Creek Reservoir, 1036 m, 6 Jul 1993, *Ahart 7052* (CHSC); 0.5 mi NW of Lost Creek Reservoir, 1021 m, 19 Jul 1998, *Ahart 8052* (BRU, CHSC, DAV, HSC, JEPS, WTU); same site, 6 Jul 2011, *Zika 25535* (CAS, CHSC, OSC, WTU); W side of Pinkard Creek, 1.2 road mi N of Lost Creek Reservoir dam, 6 Aug 2006, *Janeway 8826* (CHSC, WTU); same site, 6 Jul 2011, *Zika 25536* (CAS, CHSC, GH, JEPS, MICH, MO, OSC, UCR, WTU); upper W branch of Know-Nothing Creek, Lumpkin Ridge Road, 1219 m, 7 Jul 2000, *Ahart 8558* (CAS, CDA, CHSC, JEPS, NY, RM, RSA, SD, WTU); same site, 28 Jul 2002, *Janeway 7689 & Castro* (JEPS, CHSC); same site, 3 Aug 2006, *Waterway 2006.160 & Janeway, Lechowicz* (MTMG); same site, 5 Aug 2011, *Zika 25713 & Wilson, Ahart, Janeway* (CAS, CHSC, JEPS, OSC, RSA, WTU); large bare granite opening 1.1 km NE of Little Bald Rock, 1009 m, 22 May 2007, *Ahart 13912* (CHSC, JEPS, WTU); same site, 10 Jul 2007, *Janeway 9112 & Ahart, Hanson* (WTU); same site, 5 Aug 2011, *Zika 25712 & Wilson, Ahart, Janeway* (CHSC, OSC, WTU). **El Dorado Co.:** bog along Slab Creek, 0.25 mi W of Kings Meadow, E of Pino Grande, 1340 m, 11 Jul 1968, *Stebbins 6757* (CAS); Kings Meadow, near headwaters of Slab Creek, 1359 m, 23 Aug 2006, *Janeway 8860* (CHSC, WTU); upper Gaddis Creek near Mainline Road, Blodgett Forest, Georgetown Divide, 1310 m, 17 Jul 1973, *Rubtzoff 7088 & Howell* (CAS); same site, 24 Aug 2006, *Janeway 8868* (CHSC, WTU); S Fork Bacon Canyon near Bacchi Corral Road, Blodgett Forest, 1295 m, 19 Jul 1973, *Rubtzoff 7182 & Howell* (CAS); same site, 19 Jul 1973, *Rubtzoff 7187 & Howell* (CAS); Rock Canyon Creek, 200 m upstream of confluence with Traverse Creek, Traverse Creek Special Interest Area, El Dorado National Forest, 680 m, 8 Jul 2007, *Janeway 9080* (CHSC, WTU); same site, 17 May 2012, *Zika 25877 & Janeway* (CHSC, OSC, WTU). **Yuba Co.:** Hampshire Creek Meadow, 1.5 air km E of Clipper Mills, Plumas National Forest, 1026 m, 13 Jul 2007, *Janeway 9116 & Ahart, Hanson* (WTU); same site, 7 Aug 2007, *Ahart 14419* (CHSC); same site, 5 Aug 2011, *Zika 25718 & Wilson, Ahart, Janeway* (CHSC, JEPS, OSC, WTU).

We examined the available types of *Carex mendocinensis*, *C. gynodynama* Olney, and their synonyms (*C. cinnamomea* Olney, *C. debiliformis* Mack. and *C. blankinshipii* Fernald), as well as 300 herbarium specimens, to establish the differences between them and *C. cyrtostachya*. We also wanted to ensure that none of the names in synonymy might apply to *C. cyrtostachya*. The descriptions of several of these taxa clearly stated or implied which gathering was the type, but failed to specify which duplicate was the holotype. In addition, part of the type series of *C. mendocinensis* was a hybrid with *C. gynodynama*. Consequently, several notes on typification and some lectotypifications were needed. The types of *C. gynodynama* and *C. mendocinensis* were numbered consecutively by Bolander and appear to be from a large mixed population that included hybrids. Like Howell (1951) we believe it is reasonable to assume they were all collected on the same date at the same place. One of the duplicates, at DS, has the precise date of collection, 11 May 1866. William Boott described *C. mendocinensis*; his original material at Harvard is the lectotype selected below, and the specimen is consistent with his protologue. Howell (1951) noted the material in Boott's herbarium was not a mixed collection (*Bolander 4701* GH, ex herb. W. Boott), and we agree. However, some of the isotypes we annotated from BH, BM, BRU, and US were mixed collections of *C. mendocinensis* with the similar-looking sterile hybrid *C. gynodynama* × *C. men-*

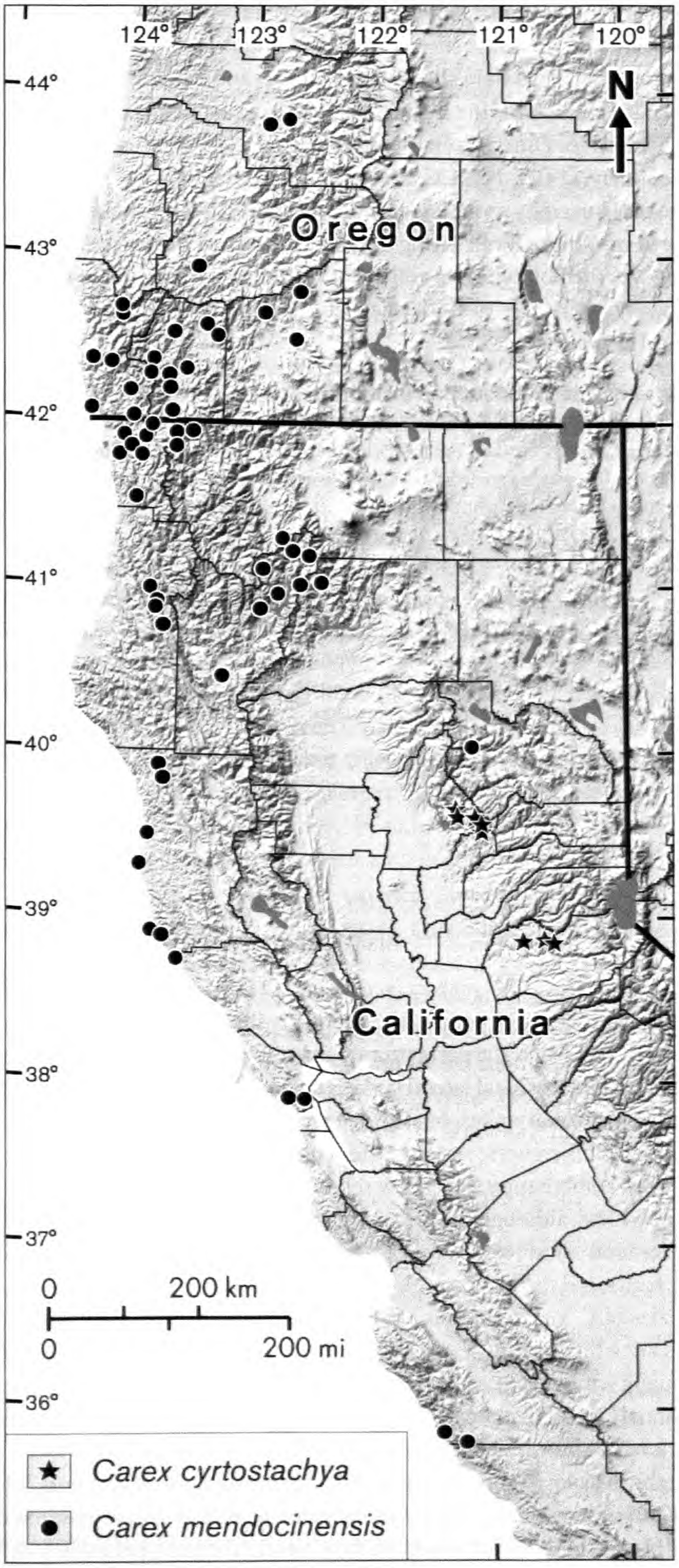


FIG. 5. Distribution of *Carex cyrtostachya* and *C. mendocinensis*, based on verified herbarium vouchers.

docinensis. The hybrid plants fail to exsert or dehisce their anthers and thus can be distinguished from the type material of *C. mendocinensis* on the same sheets, which, although often immature, has dehiscent anthers or exserted filaments where the anthers were shed. Howell (1951) and Waterway (1988) reported isotypes of *Bolander 4701* at NY were also a mix with the hybrid, but we were unable examine them. We also inspected the available types of *C. cinnamomea* Olney, a synonym of *C. mendocinensis*. Howell (1951) discussed the taxonomy and cited type specimens at GH, NY, UC, and US, but did not select a lectotype. We designate Olney's original material at Brown University as the lectotype (*Bolander 6477* BRU, ex herb. S. T. Olney). *Carex gynodynama* was also described by Olney (1868), citing only one gathering, *Bolander 4700*, but not specifying which of the many duplicates was the holotype. Howell (1951) effectively lectotypified the name by citing *Bolander 4700* (BRU) as the type. We were able to study the lectotype and nine isotypes of *C. gynodynama*; none appeared to include hybrid elements.

Carex mendocinensis Olney ex W. Boott, Bot. California 2:249. 1880. TYPE: U.S.A. CALIFORNIA. Mendocino Co.: swamps near Mendocino City, spring [11 May] 1866, *H. N. Bolander 4701* (LECTOTYPE, here designated: GH (bar code 342878, ex herb. W. Boott, right side of sheet)!; ISOTYPES: BH (bar code 53976, inflorescence on far left, and inflorescence 4th from right margin, the rosettes and remaining 6 inflorescences are hybrids, *C. gynodynama* × *C. mendocinensis*)!, BH (bar code 53977)!, BM (two center plants, hybrids on extreme left and right)!, BRU (left side of sheet, hybrid on right)!, CAS (fragment)!, DS!, GH (bar code 342876, left side of sheet)!, K(2)!, NY (2), POM!, UC(2), US29453 (bar code 26804, left and right side of sheet, hybrid in middle)!, US319264 (bar code 1105537, right side of sheet, hybrid on left side)!).

Carex cinnamomea Olney, Proc. Amer. Acad. Arts 7: 396. 1868. Not *Carex cinnamomea* Boott, Proc. Linn. Soc. Lond. 1:257. 1846. *Carex debiliformis* Mack., Bull. Torrey Bot. Club 37:244. 1910. TYPE: U.S.A. CALIFORNIA [incorrectly cited as Humboldt Co. in the protologue, but in modern Mendocino Co., which is how Bolander labeled isotypes at GH, K, and US; extant and common in 2012]: In swamp on Red Mountain, [11 Apr–24 May] 1866, *Bolander 6477* (LECTOTYPE, here designated: BRU (bar code 8, ex herb. S.T. Olney)!; ISOTYPES: BH(3)!, BM!, BRU (bar code 7)!, CAS(fragment)!, CU, DS, GH(2)!, K!, MO, NY, UC, US(2)!).

Carex gynodynama Olney, Proc. Amer. Acad. Arts 7:394. 1868. TYPE: U.S.A. CALIFORNIA [Mendocino Co.]: swamps near Mendocino City, [11 May] 1866, *Bolander 4700* (LECTOTYPE, designated by Howell 1951, p. 160: BRU!; ISOTYPES: BH(3)!, CAS!, CU, DS!, GH(2)!, MO(2), NY(2)!, PAC, POM, UC(3), US).

Carex blankinshipii Fernald, Erythrea 7:121. 1899. TYPE: U.S.A. CALIFORNIA. Humboldt Co.: Hydesville, 19 Jun 1893, *Blankinship s.n.* (HOLOTYPE: GH!, ISOTYPE: BH(fragment)!).

DISCUSSION

Carex cyrtostachya is closely related to *C. mendocinensis*, and the two are compared in Table 1. Most specimens are easily segregated by inflorescence structure. The lateral pistillate spikes of *Carex cyrtostachya* arch or droop, or dangle on flexuous peduncles, and the perigynia are more widely spaced (Figs. 1, 2A). *Carex mendocinensis* usually displays erect or ascending distal lateral spikes that are densely fruited (Fig. 2B). Occasional plants of *C. mendocinensis* show lax proximal spikes, but the distal pistillate spikes remain essentially erect. In addition to the obvious inflorescence differences, several other characters are useful in identification. Although none are absolutely exclusive, in combination they allow reliable identification. The staminate scales of most plants of *C. mendocinensis* are awnless, although the lower scales rarely have an awn 0.3–0.5 mm (e.g., *Peck 8792* (GH), Curry Co., Oregon). Proximal staminate scales of *C. cyrtostachya* have prominent awns, often 1–5 mm long. In addition, the pistillate scales and their awns are longer in *C. cyrtostachya*, with some overlap in measurements. The perigynia and scales of *C. mendocinensis* are green, strongly marked with red or purple or red-brown; rarely the scale bodies are white-hyaline, especially when immature. In contrast, the pistillate scale bodies of *C. cyrtostachya* are usually white-hyaline, only rarely with a faint red-brown wash, whereas the perigynia are green with only occasional faint or inconspicuous red or purple dots. Some specimens of *C. mendocinensis* have perigynia entirely dark red or purple, something that is never seen in *C. cyrtostachya*. The perigynium shape and size is similar, but the discolored stipe is usually 0.1–0.3 mm for *C. mendocinensis*, while it is usually longer in *C. cyrtostachya*, 0.3–0.5 mm. Similarly, the achene placement within the perigynium differs slightly, so that the distance between the base of the achene body and the base of the perigynium is 0–0.7(–0.9) mm in *C. mendocinensis* and (0.5–)0.7–1.2 mm in *C. cyrtostachya* (Fig. 3). The upper culm, inflorescence rachis, or peduncles of *C. mendocinensis* are often scabrous, while they tend to be smooth or faintly scabrous in *C. cyrtostachya*.

TABLE 1. Comparison of *Carex mendocinensis* and *C. cyrtostachya*. Based on measurements from 30 representative specimens of each species.

Character	*C. mendocinensis*	*C. cyrtostachya*
Foliage	glabrous, occasionally hairy near blade base	glabrous, rarely hairy near blade base
Ligules	apex acuminate, acute, rounded or notched, 1.6–6.5(–11) mm	apex acute to acuminate, 1.1–12.6 mm
Anther length	1.8–3.4 mm	1.8–3 mm
Distance between perigynia in mid-spike, distal spikes	usually densely packed, 0.3–0.6(–1.2) mm	usually well separated, 0.7–3.5(–6) mm
Aspect of distal spikes	usually erect or ascending	arching or drooping
Pistillate scale color	midvein green, body usually streaked or marked with red-brown to purple-brown, rarely white hyaline	midvein green, body white hyaline or faintly marked with red-brown
Pistillate scale length including awn	1.7–3.2(–3.7) mm	(2.2–)3–4.8(–6.8) mm
Pistillate scale awn length	0–0.3(–2) mm	(0–)0.5–1.5(–3.1) mm
Proximal staminate scale awn length	0(–0.5) mm	(0.3–)0.5–5 mm
Perigynium stipe	0.1–0.3(–0.5) mm	0.3–0.6 mm
Perigynium color	green, aging brown, often with red to purple splotches or dots; occasionally entirely dark purple	green, aging brown; occasionally with red or purple dots; never entirely dark purple
Substrate preference	mostly on serpentine, saturated soil	mostly off serpentine, mesic to saturated soil

Carex mendocinensis hybridizes with *C. gynodynama* (Howell 1951; Waterway 1990b). We found no potential hybrids or intermediate morphologies between *C. mendocinensis* and *C. cyrtostachya*. The two are not known to grow together; they are disjunct by 200 km (Fig. 5), with a single exception. An occurrence of *C. mendocinensis* in the northern high Sierra Nevada of Plumas County was discovered by Lowell Ahart in 2000 (*Ahart 8381* CHSC), where the two species are separated by only 40 km.

Carex cyrtostachya, with its long, loosely-fruiting arching to drooping pistillate spikes, closely resembles *C. arctata* Boott and *C. debilis* Michx. in eastern North America. There is a gap of more than 2000 km in their ranges, and they differ in foliar and perigynium characters. *Carex arctata* has broader and more evergreen basal leaves, and perigynia with shorter stipes and longer beaks. *Carex debilis* has, among other differences, longer perigynia with less distinct beaks (Waterway 2002). In tropical America *C. flexirostris* Reznicek and *C. perlonga* Fernald are superficially similar to *C. cyrtostachya*, but the latter is separable from these by its uniformly pistillate lateral spikes, straight perigynium beak, and awned staminate scales (Reznicek 1986).

For now we follow the taxonomy of Reznicek (1986) and Waterway (2002) in defining *Carex* sect. *Hymenochlaenae*, although molecular work in progress suggests the sectional alliances may change in the future (Waterway & Starr 2007). Six similar species from the section are contrasted in the key below. Five are native in Oregon and California, and one (*C. sylvatica* Huds.) is adventive in the Pacific Northwest.

KEY TO *CAREX CYRTOSTACHYA* AND SIMILAR SPECIES IN WESTERN NORTH AMERICA

1. Leaf sheaths at culm (stem) bases light brown to dark brown; terminal spike staminate (rarely staminate/pistillate/staminate)
   2. Distal lateral spikes often androgynous or staminate; perigynia pubescent, with 2 strong ribs and 12–20 veins; lateral spikes 6–15, sometimes more than one spike per node; endemic to southern California _____ **C. obispoensis** Stacey
   2. Distal lateral spikes pistillate; perigynia glabrous, with 2 strong ribs and no conspicuous veins; lateral spikes 3–5, always solitary at nodes; naturalized in western British Columbia and western Washington _____ **C. sylvatica** Hudson
1. Leaf sheaths at culm bases dark purple; terminal spike staminate or gynecandrous (rarely androgynous)
   3. Leaf blades and sheaths glabrous or leaf base and sheath apex sparsely hairy; basal or rosette leaves 2–6 mm wide, usually less than 5 mm wide; perigynia usually glabrous, rarely sparsely appressed-hairy near beak in *C. mendocinensis*.
      4. Distal lateral spikes loose and arching or drooping; proximal staminate scales with awns 0.5–5 mm long; pistillate scales, including awns, usually 3–4(–6.8) mm long, the awns usually 0.5–1.5(–3.1) mm long _____ **C. cyrtostachya** Janeway & Zika

4. Distal lateral spikes dense and erect or ascending; proximal staminate scales awnless (rarely with short awn 0.3–0.5 mm); pistillate scales, including awns, usually 1.7–3.2(–3.7) mm long, the awns usually 0–0.3(–2) mm long ____ **C. mendocinensis** Olney ex W. Boott

3. Leaf blades and sometimes sheaths densely hairy; basal or rosette leaves occasionally 7–12 mm wide; perigynia usually conspicuously long- spreading-hairy, rarely glabrous in *C. hirtissima*.
   5. Pistillate scales red-brown or purplish with a green midrib; perigynia splotched with purple; coast ranges of Oregon and California ____ **C. gynodynama** Olney
   5. Pistillate scales green, white, or pale red-brown with a green midrib; perigynia sometimes red-dotted but not splotched with purple; coast ranges and west slope of Sierra Nevada in California ____ **C. hirtissima** W. Boott

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BOOK REVIEW

AMY STEWART. 2013. **The Drunken Botanist: The Plants that Create the World's Great Drinks.** (ISBN: 978-1-61620-046-6, paper overboard). Algonquin Books, P.O. Box 2225, Chapel Hill, North Carolina 27514-2225, U.S.A. (**Orders:** www.amystewart.com). $19.95, 368 pp., 2-color illus., 6" × 8".

Amy Stewart got the idea for this book when she went to a liquor store and saw, in her wonderful imagination, instead of bottles of liquor, the plants that make the drinks we know and love—or don't know and don't love as the case may be. Her vision inspired a great little book for imbibers, botanists, gardeners, chemists, bacteriologists, and historians.

The book is handily sectioned into plants from which we create alcohol, the plants we use to flavor alcohol, and the plants we use to garnish our drinks. Each of these sections is in alphabetical order, making it easy to find something specific. The index is quite detailed and is also helpful for anyone doing research. (The recipes listed in the front of the book save time!)

In Part I, we are introduced to the plants used to make alcohol as well as the plants we use to age the brew. This includes mostly grasses, fruit, and vegetables used to create alcohol. There are only a few oaks currently used to make barrels in which rough spirits are tamed into the smooth scotch, whiskey, rye, rum, gin, & vodka, with which we are familiar.

The history of various beverages is fascinating, and along the way Stewart debunks a myth or two. For instance, vodka was made of grains long before the potato even arrived in Europe. Apparently Russia and Poland still quarrel over who invented the beverage. The history and importance of yeast in the whole process is thoroughly and delightfully covered. Without the yeast, we would have no alcohol. My favorite category of side articles in the book is "Bugs 'n' Booze." Earthworms, honeybees, and whatever falls off the rafters into the fermenting vat can bring yeast, flavor, and color to the mix.

Part II of the book covers the flavors we give to various alcoholic beverages. From allspice to wormwood, angostura to sugar maple, apricot to yuzu, and almonds to walnuts, the reader is led through a garden of flavors. Given her directions, you could grow your own hops or sloes or citrus!

In addition, Ms. Stewart provides quite a few recipes and not a few horticultural tips on which species to select and the prime conditions for growing various plants. There is a recipe for Capillaire syrup which uses several stems of fresh maidenhair fern, water, sugar, and orange flower water. The resulting syrup comes in handy if you wish to create Jerry Thomas Regent's Punch.

Stewart winds up her book with garnishes for various drinks. Herbs, flowers, berries, vines, fruits, and vegetables are touted here. A template for experimental garden cocktails will send you to your garden or the local farmer's market to try some or all of the recipes. You will be encouraged to grow your own berries, fruit and vegetables in a garden made exclusively for cocktails. She makes it sound easy.

The Drunken Botanist is a really fun read. Lots of facts are crammed into the book, but Ms Stewart keeps it light and entertaining. It is filled with fun facts for cocktail hour small talk and would make a great gift for anyone who likes cocktails.—*Kay Yount, Tarrant County Master Gardener & Volunteer at the Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

A RE-EVALUATION OF *CAREX SPECUICOLA* AND THE *CAREX PARRYANA* COMPLEX (CYPERACEAE)

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ABSTRACT

We review the systematics and provide a key for the *Carex parryana* complex (sect. *Racemosae*). *Carex specuicola* is recognized as a hanging gardens endemic, while a similar species, **C. utahensis,** is found in a diversity of wetlands in Utah and westernmost Colorado. We reinstate "*C. aboriginum*" of older literature as a good species with the new name of *C. holmgreniorum*. We confirm the distinctness of *C. hallii*, *C. idahoa*, and *C. parryana* and provide additional characters for distinguishing these taxa. The type of *Carex hallii* is reinterpreted to be consistent with the protologue. A lectotype is chosen for *Carex idahoa*.

RESUMEN

Se revisa la sistemática y se aporta una clave para el complejo de *Carex parryana* (sect. *Racemosae*). *Carex specuicola* se reconoce como endemismo de jardines colgantes, mientras que una especie similar, **C. utahensis,** se encuentra en vrios humedales de Utah y extremo occidental de Colorado. Se reinstaura "*C. aboriginum*" de la biliografía antigua como una buena especie con el nuevo nombre de *C. holmgreniorum*. Se confirma la diferencia de *C. hallii*, *C. idahoa*, y *C. parryana* y se aportan caracteres adicionales para distinguir estos taxa. Se reinterpreta el tipo de *Carex hallii* para que sea consistente con el protólogo. Se escoje un lectotipo para *Carex idahoa*.

INTRODUCTION

Plants referred to *Carex parryana* Dewey have always been a source of taxonomic difficulty. Adding to this difficulty is that, even though some species are widespread, all are uncommon or rare. *Carex parryana* and its close relatives differ from other members of section *Racemosae* in having ±elongated inflorescences that have relatively narrow (2.4–6.8 mm wide), cylindrical, erect or ascending lateral spikes (if not unispicate), combined with small perigynia 1.7–3.3 mm long (–3.9 in *C. specuicola* and *C. utahensis*). Mackenzie (1935) recognized four species in this complex, *C. aboriginum* M.E. Jones, *C. hallii* Olney, *C. idahoa* L.H. Bailey, and *C. parryana*. Murray (1969) recognized *C. parryana* as one variable species consisting of distinct races in the southern Rocky Mountains, and treated them as subspecies; *C. parryana* subsp. *hallii* (Olney) D.F. Murray, *C. parryana* subsp. *idahoa* (L.H. Bailey) D.F. Murray and *C. parryana* subsp. *parryana*. He did not treat *C. aboriginum*, realizing that "*Carex aboriginum*" as described in Mackenzie (1935) was close to *C. parryana* and a quite different plant than *C. aboriginum* M.E. Jones, which is a local Idaho endemic with much larger perigynia (4.7–)5–6.6 mm long very similar to *C. serratodens* W. Boott (Murray 2002). Hermann (1970) recognized *C. hallii*, *C. idahoa*, *C. parryana*, and *C. aboriginum* M.E. Jones as species, but noted that "*Carex aboriginum*" as described in Mackenzie (1935) is "completely different" from M.E. Jones's type's type. He treated *C. aboriginum* of Mackenzie, not M.E. Jones, as *C. parryana* var. *brevisquama* F.J. Herm. Murray (2002) treated *C. idahoa*, *C. hallii*, *C. parryana*, and *C. aboriginum* as species, and also noted that Mackenzie's "*C. aboriginum*" was not *C. aboriginum* of M.E. Jones, but did not recognize *C. parryana* var. *brevisquama*. Finally, Goodrich (in Welsh et al. 2003) concluded that *C. specuicola*, described by Howell (1949) as an endemic of hanging gardens in northern Arizona, also belonged within *C. parryana*, and recognized only *C. parryana* in Utah.

In the last decade of floristic activity within the range of the *Carex parryana* complex, there has fortunately been enough collecting to generate a great many new specimens. This was especially true for *Carex specuicola*, for which few specimens existed when it was treated for Flora of North America, (Murray 2002). Botanists working with the Navajo Nation (see Roth 2004) discovered a number of new populations, and we

now have an excellent series of specimens to study. We reviewed these new collections with several questions in mind. Is *C. specuicola* a good species? Is recognition of *C. hallii*, *C. idahoa*, and *C. parryana* as species supported by additional collections? Finally, what is the identity of "*Carex aboriginum*" of Mackenzie (1935) not M.E. Jones (= *C. parryana* var. *brevisquama* F.J. Herm.), and is it a good species? We also provide illustrations of all the poorly known entities.

RESULTS

Plants referred to *Carex parryana* divide into two clear groups based on morphology and geography. One group, including *C. specuicola*, has strongly flattened perigynia much larger than and loosely fitting over the achenes, an admixture of 2-styled and 3-styled flowers, and is essentially confined to Utah and Arizona. The other group, including *C. hallii*, *C. idahoa*, *C. parryana*, and "*C. aboriginum*" of Mackenzie not M.E. Jones, with the perigynia tightly enveloping the achene and entirely 3-styled flowers, is widespread, occurring from Ontario to Alaska, but south only to Colorado, Utah, Nevada, and California.

The former group, with loosely fitting perigynia and a mix of 2-styled and 3-styled flowers consists of two species. One is the lax hanging garden endemic *Carex specuicola* with pale perigynia. In addition, we recognize an essentially allopatric and more widespread species from a diversity of wetland habitats that is usually stiffly upright, with clearly purple-tinted perigynia, which we describe as *C. utahensis*. In the latter group, with perigynia tightly enveloping the achenes, the plants erroneously referred to *Carex aboriginum* by Mackenzie (1935), and later described as the poorly known *C. parryana* var. *brevisquama* stand out clearly by having large perigynia 2.5–3.3 mm long and 1.5–2.3 mm wide, broad achenes 1.3–1.6 mm wide, and broad lateral spikes, the widest 4–6.8 mm wide. We recognize this taxon at species rank and describe it herein as *C. holmgreniorum*. The remaining three entities, *C. hallii*, *C. idahoa*, and *C. parryana* have smaller perigynia 1.7–2.8 mm long and 0.9–2 mm wide, narrower achenes 0.8–1.2 mm wide, and often narrower (or no) lateral spikes at most to 3.6 mm (5.5 mm in *C. idahoa*) wide. These three remaining species of the *Carex parryana* complex as recognized in Murray (2002) are re-evaluated and confirmed as distinct, with additional diagnostic features that appear to be stable with the larger sample now available.

Carex idahoa is the most easily distinguished entity. It has dark pistillate scales, which are clearly longer than the subtended perigynia, and are frequently sharply pointed. In contrast, *C. hallii* and *C. parryana* have paler, usually rounded-obtuse to acute scales shorter than to about as long as the subtended perigynia. The lateral spikes of pistillate plants, present in about 75% of culms, are also relatively broad, 3–5.5 mm wide. Lateral spikes of *C. hallii* and *C. parryana* (always pistillate) are (2.2–)2.4–3.6 mm wide.

Carex hallii and *C. parryana* show great variability in inflorescence size, spike number, and spike sexuality. Nevertheless, most culms of *Carex hallii* (87% of a herbarium sample of 106 inflorescences) had only one or two spikes (i.e., a terminal spike and a single lateral spike), while less than 5% of a similar sample of *C. parryana* inflorescences had only 2 spikes (none having only one). Figure 1 shows the strikingly different distribution of spike number in these two species. In those culms of *C. hallii* with inflorescences bearing more than one spike, and thus potentially confusable with *C. parryana*, the terminal spike is usually more than twice as long as the longest lateral spike. In *C. parryana*, the terminal spike is usually less than twice as long as the longest lateral spike. In addition, *C. parryana* is a larger plant, with culms often as tall as 35–60 (–70) cm, while *C. hallii* is rarely more than 35 cm tall. Figure 2 contrasts the terminal spike length/longest lateral spike length with culm height for culms of *C. hallii* with multispicate inflorescences and *C. parryana*. This figure also shows that *C. hallii* and *C. parryana* do not represent two ends of a uniform spectrum of variation in size and inflorescence structure, but show this variation arrayed in distinctively different patterns.

KEY TO THE *CAREX PARRYANA* GROUP

1. Achenes occupying only the proximal ½–⅔ of the perigynium, distal portion and sides empty; perigynia herbaceous to membranous, strongly flattened or concavo-convex.
   2. Culms flexuous, spreading and arching; perigynia broadly elliptic, green to pale brown distally, purple tinged only near the base of the beak, whitish hyaline proximally, achene clearly visible through the perigynium; pistillate scales

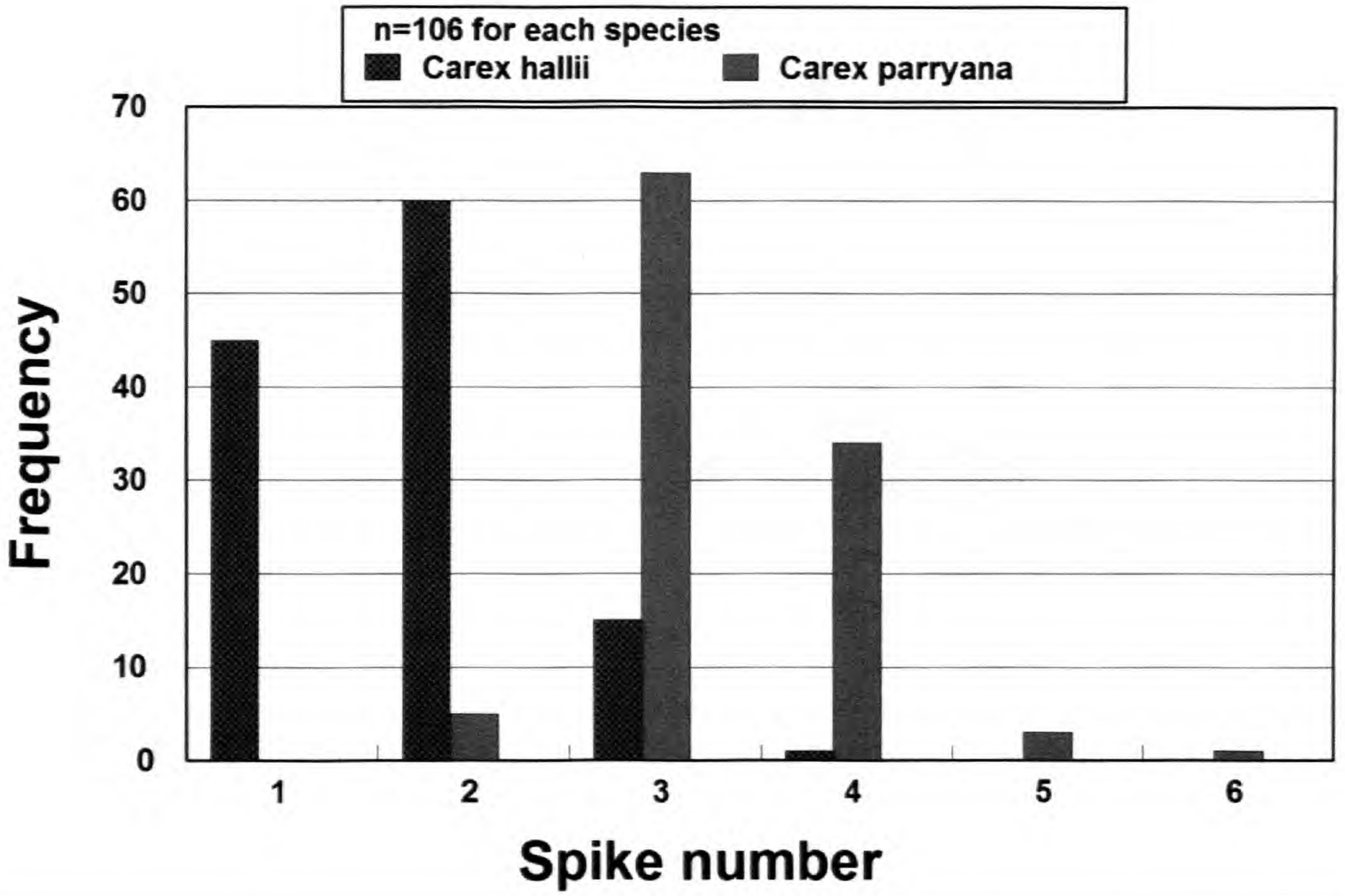


FIG. 1. Distribution of spike numbers in *Carex hallii* and *C. parryana*.

0.9–1.5 mm wide, reddish-brown with broad hyaline margins; stigmas mostly 2 (up to ca. 30% 3); "hanging gardens" ____ **1. Carex specuicola**

2. Culms stiff, erect and straight; perigynia obovate, strongly purple tinged distally, greenish and opaque proximally, achene not clearly visible through the opaque perigynium; pistillate scales 1.3–1.9 mm wide, deep purple-brown with narrow, inconspicuous hyaline margins; stigmas mostly 3; various wet habitats ____ **2. Carex utahensis**

1. Achene ±filling the perigynium; perigynia coriaceous, ±rounded trigonous to plumply biconvex, not strongly flattened.
   3. Pistillate scales dark reddish-brown to purple-black, the largest (at middle of terminal spikes) (2.5–)3–4.2 mm long, the proximal scales acute to acuminate and clearly exceeding the perigynia ____ **6. Carex idahoa**
   3. Pistillate scales pale reddish-brown to reddish-purple, the largest (at middle of terminal spikes) 1.6–3(–3.2) mm long, rounded-obtuse to acute, shorter than to about as long as the perigynia.
      4. Achenes 1.3–1.6 mm wide; lateral spikes always present, the largest 4–6.8 mm wide ____ **3. Carex holmgreniorum**
      4. Achenes 0.8–1.2 mm wide; lateral spikes present or absent, if present, then ca. (2.2–)2.4–3.6 mm wide.
         5. Spikes (2–)3–4(–6), the terminal spike usually gynaecandrous, less commonly male or female, mostly 0.7–2(–2.3) times as long as the longest lateral spike; perigynium body below the base of the beak papillose and usually with at least some short, pointed hairs, especially on the angles ____ **4. Carex parryana**
         5. Spikes 1–3(–5), usually unisexual, if spikes more than one, then the terminal spike (1.8–)2–5.5 times as long as the longest lateral spike; perigynium body below the base of the beak ±papillose but usually lacking short, pointed hairs ____ **5. Carex hallii**

1. Carex specuicola J.T. Howell, Leafl. West. Bot. 5:148. 1949. TYPE: UNITED STATES. ARIZONA: Coconino Co.: along trail from Inscription House Post to Inscription House Ruin, 23 Jun 1948, *J.T. Howell 24609* (HOLOTYPE: CAS 342553!; ISOTYPES: MICH!, NY!).

Loosely cespitose to slightly colonial from slender, ±elongate rhizomes 0.9–2.3 mm wide, rhizomes ca. 0.5–7 cm long between shoots, rhizome scales pale brown, rapidly disintegrating into fibers; culms (7.5–)19–70(–115) cm, lax, flexuous and arching or drooping, trigonous, smooth to finely papillose, 0.5–1 mm wide immediately below the inflorescence; phyllopodic, cataphylls and basal sheaths pale to dark brown, youngest sometimes tinged reddish-purple. Leaves 5–11, essentially basal; blades 1.8–38 cm long, 0.8–3.3(–4.5) mm wide, much shorter than culms, ±folded, the margins and midrib smooth to finely antrorsely scabrous distally,

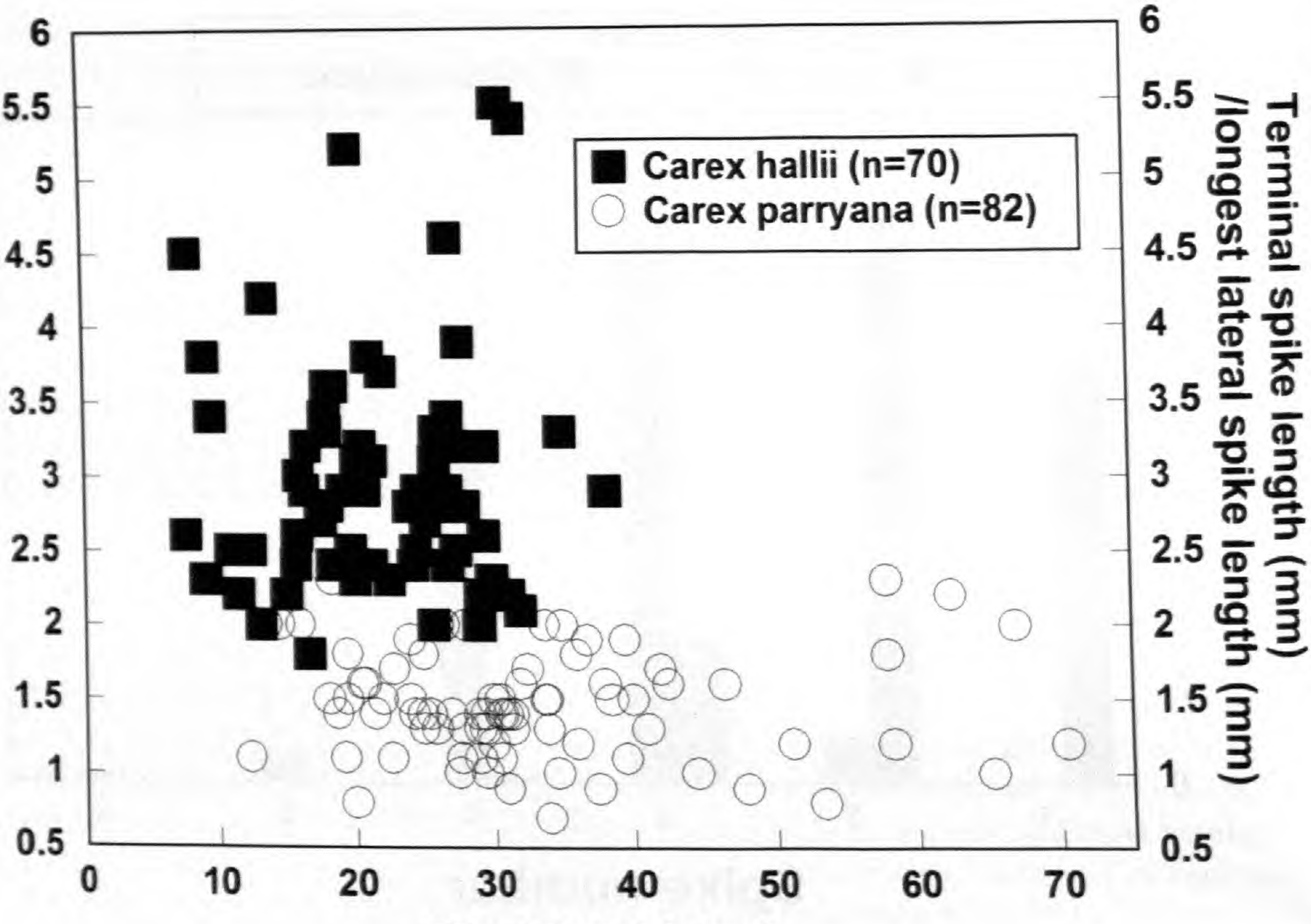


Fig. 2. Plant height versus spike proportion in *Carex hallii* and *C. parryana*.

±smooth adaxially, ±papillose abaxially, especially distally; leaf sheaths 1.5–13 cm long, glabrous, ventrally whitish or pale brown, sometimes finely brown streaked, hyaline, thin, concave at the apex; ligules ca. (1.5–)2–8(–10) mm long, obtuse or retuse to long-acute, longer than wide, at least on the uppermost culm leaves, free portion whitish to pale brown. Inflorescences 1–9.5(–11.5) cm long, with (1–)2–4(–5) spikes, terminal gynaecandrous or occasionally staminate, pistillate, or mixed, laterals pistillate; lateral spikes separate or uppermost ±overlapping, the lower two spikes 0.3–2(–8) cm distant, lowermost ±sessile or on a smooth to ±papillose peduncle up to 13(–18) mm long; lowermost bracts ±bristle-like to leaf-like, blades 1.3–12 cm long up to 2.1 mm wide, sheathless, upper bracts abruptly reduced. Terminal spike 9–29 mm long, pistillate portion (0–)1.8–17 mm long, 3.3–6.5 mm wide, ca. (0–)3–45-flowered, staminate portion (0–)3.3–23 mm long, 1–2.6 mm wide, ca. (0–)4–60-flowered, peduncle 1.2–13.2 mm long. Lateral spikes 5–31 mm long, 2.7–5.2 mm wide, cylindric, lowest occasionally with a small branch, densely flowered with ca. 5–60 ascending perigynia. Staminate scales 2.6–4.9 mm long, 1.1–1.6 mm wide, narrowly obovate, pale brown to reddish-brown with hyaline margins, apex ±obtuse to acute or acuminate, green, 1–3-nerved center, sometimes prolonged into a ±scabrous-ciliate apiculus or short awn up to 1.5 mm long. Pistillate scales 1.6–3.2 mm long, 0.9–1.4(–1.7) mm wide, pale brown to reddish-brown with conspicuous hyaline margins, ovate to ±oblong, obtuse to acute, green 1–3-nerved center sometimes prolonged into a scabrous-ciliate apiculus or awn up to 1.1 mm long. Perigynia 2.4–3.8 mm long, 1.2–2.2 mm wide, ±strongly flattened in cross-section, broadly to narrowly elliptic, not filled by the much smaller achene, ±membranous, somewhat papillose distally, green to brown on the upper margins and sides, often reddish-purple tinged near the base of the beak, otherwise whitish hyaline and ±translucent, 2-nerved, tapering to a short stipitate base, ±abruptly contracted into a cylindrical beak; beaks 0.2–0.45 mm long, smooth to somewhat papillose, sometimes slightly setulose, green to purplish-brown, apex ±erose to bidentulate with teeth up to 0.2 mm long. Achenes 1–1.9 mm long, 0.8–1.35 mm wide, concavely tapering to a slender

stipe 0.2–0.45 mm long, lenticular or occasionally flattened-trigonous in cross section; the convex sides elliptic to nearly circular in lenticular achenes, narrowly elliptic in trigonous achenes, brown, smooth; apex apiculate with an apiculus up to 0.15 mm formed by the persistent style base; the style deciduous; stigmas mostly 2, sometimes up to 30% 3. Anthers 3, 1.2–2.7 mm long, with a conspicuous apiculus ca. 0.1–0.3 mm long.

Moist seeps in shallow caves or alcoves along sandstone cliffs—"hanging gardens." *Carex specuicola* occurs as local populations consisting of a few culms to as many as 400–500 plants spread over many meters of the cliff face. Elevation 1350–2325 m. Endemic to northern Arizona and immediately adjacent southernmost Utah.

This is an endemic of Navajo sandstone "hanging gardens." Typical associated species of hanging gardens in the region include *Adiantum capillus-veneris* L., *Anticlea vaginata* Rydb., *Aquilegia micrantha* Eastw., *Cirsium rydbergii* Petr., *Epipactis gigantea* Hook., *Mimulus eastwoodiae* Rydb., *Platanthera zothecina* (Higgins & S.L. Welsh) Kartesz & Gandhi, and a few other *Carex*, especially *C. hassei* L.H. Bailey. Though very local, this species can form a dense turf and is the dominant cover in some sites. The lax, arching habit remains constant even when the plants are growing on a horizontal surface as shown in Figure 3, though this can be difficult to discern in herbarium material. A sampling of perigynia, scales, and achenes are noted in Figure 4B and a typical inflorescence from a herbarium specimen is shown in Figure 5B.

Representative specimens. **ARIZONA. Apache Co.:** Canyon del Muerto above jct with Canyon de Chelly, 5 May 2001, *Rink 258* (NAVA, ASC); narrow canyon SW of Immanuel Mission, 27 Apr 1995, *Hevron 2276* (NAVA); Carson Mesa, 12 Jun 2001, *O'Kane, Jr. et al. 5373* (NAVA, ISTC); E side of Chinle Wash ca. 6 mi S of Tes Nez Iah and Hwy 160, 24 Sep 2003, *Roth 1735* (NAVA); Walker Creek, 1 mi S of Hwy. 160 and Mexican Water, 21 Aug 2003, *Roth 1701* (NAVA); Tseyi-hatsosi Canyon N of Kayenta and SW of Boot Mesa, 23 Jul 1991, *Hevron 1340* (NAVA); N of Giant Canyon trail, 20 May 2002, *Rink 1154* (ASC, BRY); Dancing Rocks NE of Rock Point, 21 Aug 2003, *Roth 1699* (NAVA). **Coconino Co.:** canyon S edge of Gray Mesa, 13 Jul 1989, *Hevron 214b* (NAVA); tributary to Navajo Creek, vic. of confluence with Potato Canyon, 11 Sep 2003, *Roth 1713* (NAVA). **Navajo Co.:** head of Far End Canyon N of Geshi Canyon, 30 Sep 2003, *Roth & R. Lamberson 1744* (NAVA); Tsegi watershed, Dowozhiebito Canyon, 2 Oct 2000, *Roth & Rink 923* (NAVA); Jackass Canyon, 1 Aug 2000, *Roth & Holiday 841*; small spring, W side of Long Canyon, Skeleton Mesa, 18 May 2004, *Rink & Bungart 3146* (ASC, SJNM, NAVA); spring at end of Keet Seel Canyon, 13 Sep 2000, *Rink s.n.* (NAVA); Adah Chiji Yahi Canyon, 24 May 2001, *Clifford & Heil 01-455* (NAVA); Nokai Canyon below Calamity Cave ruin, 16 Oct 2000, *Roth & Hodgson 956* (NAVA); Inscription House Spring, approx 10 mi NE of Shonto, 19 Aug 2011, *Licher 3210* (MICH). **UTAH. San Juan Co.:** E tributary to Chinle Wash ca. 1.5 mi S of San Juan R, 22 Aug 2003, *Roth 1705*; Slickhorn Canyon vic. jct with San Juan R., 5 Jun 1997, *Atwood et al. 22571* (BRY); 3 mi above San Juan R on Slickhorn Canyon, 5 Jun 1997, *Atwood & Furniss 22580* (BRY, KHD).

2. Carex utahensis Reznicek & D.F. Murray, sp. nov. TYPE: UNITED STATES. UTAH. San Juan Co.: Angel Arch Canyon, T31S, R20E, Sects. 19, 29, 30, sandy canyon bottom and juniper-pinyon covered slope, ca. 5,500 ft, 2 Jun 1964, *S.L. Welsh, G. Moore, & S.G. Canter 2998* (HOLOTYPE: BRY!).

Loosely cespitose to colonial from ±elongate rhizomes 1.3–2.7 mm thick, rhizomes ca. 1–5 cm long between shoots, rhizome scales brown to purplish-brown, disintegrating into coarse fibers; culms 22–55 cm, stiff, ±erect, trigonous, papillose, 0.5–1.4 mm wide immediately below the inflorescence; phyllopodic, cataphylls and basal sheaths brown, the youngest often reddish-purple. Leaves 6–12, essentially basal; blades 3.8–35 cm long, 1.8–4.5 mm wide, much shorter than culms, ±folded, margins and midrib smooth to finely antrorsely scabrous distally, ±smooth adaxially, papillose abaxially; leaf sheaths 1.7–15 cm long, glabrous, ventrally whitish or pale brown, hyaline, thin, shallowly concave at the apex; ligules ca. 0.8–3.7 mm long, acute to rounded, shorter than wide, free portion whitish to pale brown. Inflorescences 2.4–8 cm long, with (2–)3–5(–6) spikes, terminal gynaecandrous or occasionally staminate, pistillate, or mixed, laterals pistillate; lateral spikes overlapping or the lower separate, lower two spikes 1.3–3.3 cm distant, lowermost ±sessile or on a papillose peduncle up to 13.7 mm long; lowest bracts ±bristle-like up to 5 cm long and 1.8 mm wide, sheathless, upper bracts abruptly reduced. Terminal spike 12–31 mm long, pistillate portion (0–)3.7–19.2 mm long, 4.5–7.8 mm wide, ca. (0–)6–50-flowered, staminate portion (0–)6–24.5 mm long, 1.8–3.1 mm wide, ca. (0–)20–65-flowered, peduncle 1.8–11.5 mm long. Lateral spikes 4–22.8 mm long, 3.5–6 mm wide, cylindric, densely flowered with ca.7–40 ascending perigynia. Staminate scales 2.3–3.7 mm long, 1.2–1.9 mm wide, obovate, reddish-brown to purple with narrow hyaline margins, especially distally, apex acute to obtuse or rounded, the green, 1–3-nerved center rarely prolonged into a ±scabrous-ciliate apiculus or short awn up to 0.5 mm long. Pistillate scales 1.9–3.3 mm long, 1.3–2.2 mm wide, reddish-brown to reddish-purple, hyaline margins inconspicuous, ovate to ±oblong, obtuse to acute, the green 1–3-nerved center sometimes prolonged into a scabrous-ciliate

Fig. 3. *Carex specuicola* inflorescences from Inscription House Spring, Coconino County, Arizona.

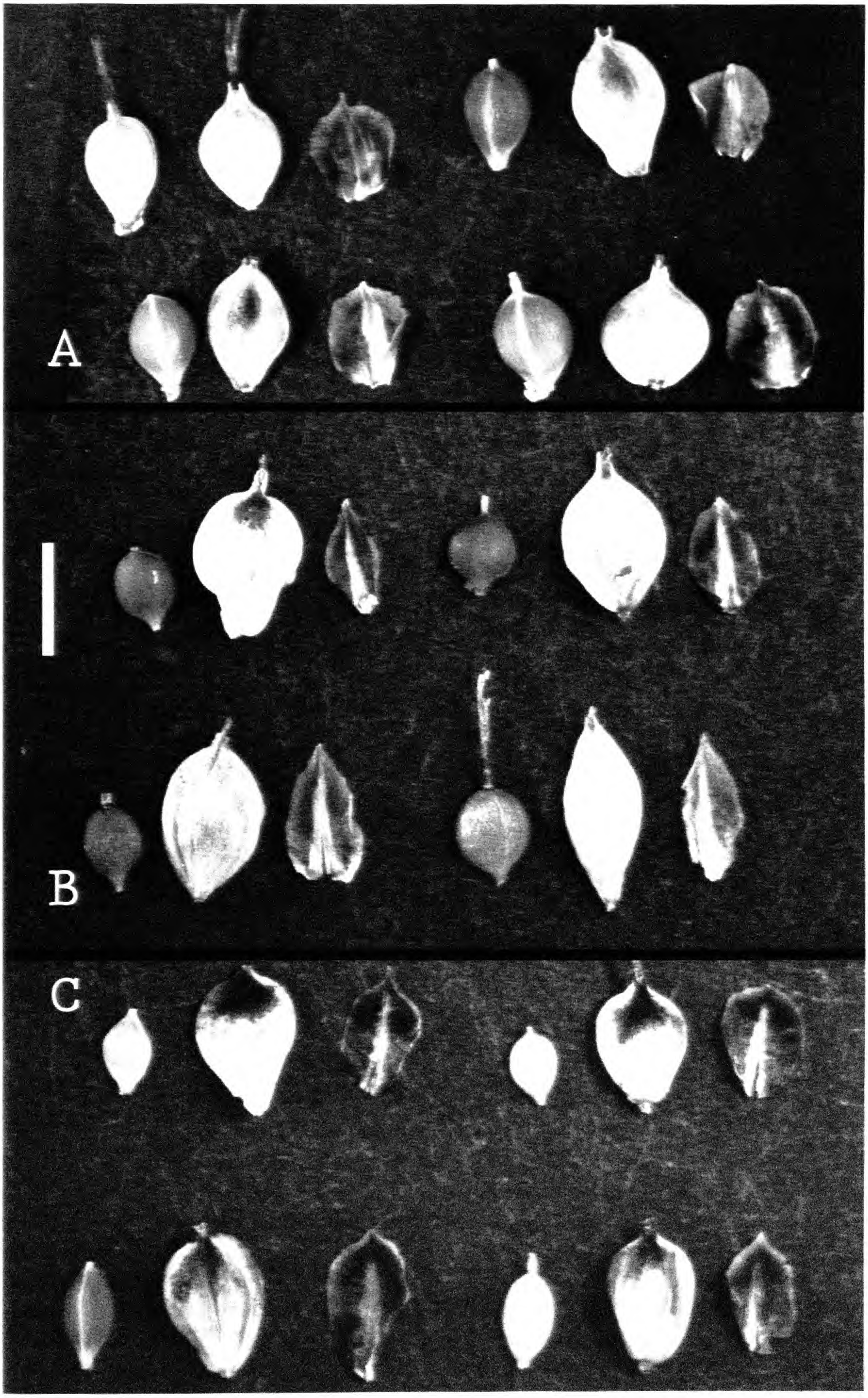


Fig. 4. Perigynia, scales, and achenes of *Carex holmgreniorum* (**A**), *Carex specuicola* (**B**) and *C. utahensis* (**C**). Scale bar = 2 mm.



Fig. 5. Inflorescences of *Carex holmgreniorum* (**A**) *C. specuicola* (**B**) and *C. utahensis* (**C**). Scale bar = 2 cm.

apiculus or awn up to 0.5 mm long. Perigynia 2.6–3.9 mm long, 1.6–2.5 mm wide, ±strongly flattened to concavo-convex in cross-section, ±obovate, not filled by the much smaller achene, herbaceous, papillose distally, green to reddish-purple distally, greenish to brown proximally, 2-nerved and frequently with a few faint nerves on the faces, tapering to a short stipitate base, contracted into an obscure to well defined cylindrical beak; beaks 0.1–0.4 mm long, papillose and sometimes setulose, green to purplish-brown, apex ±erose to obscurely bidentulate with teeth up to 0.1 mm long. Achenes 1.35–2 mm long, 0.9–1.3 mm wide, concavely tapering to a stipe 0.1–0.3 mm long, flattened-trigonous or sometimes lenticular in cross section; the convex sides narrowly elliptic in trigonous achenes, broadly elliptic in lenticular achenes, brown, smooth; apex usually apiculate with an apiculus up to 0.2 mm formed by the persistent style base; style deciduous; stigmas mostly 3, rarely up to 75 % 2. Anthers 3, 1.8–2.6 mm long, often with a conspicuous apiculus ca. 0.1–0.3 mm long.

Etymology.—From the state of Utah where the type collection is from.

Seeps, wet slopes, alcoves and hanging gardens, wet meadows, and riparian bottomlands. Elevation 1400–3000 m. Endemic to Utah and adjacent westernmost Colorado.

Plants treated as *C. parryana* in Utah by Goodrich (in Welsh et al. 2003) and mapped by Albee et al. (1988) are this species and also *C. holmgreniorum* (see below).

Carex utahensis appears to be endemic to the northern portion of the Colorado Plateau. It is similar to *C. specuicola* in having achenes much smaller than the perigynia, the perigynia thus loosely fitting around the achene and not filled by it. But *C. utahensis* is a more stiffly erect plant, with darker pistillate scales, and opaque, green and clearly obovate perigynia distinctly purple tinged apically. *Carex specuicola* has a lax, arching habit, paler pistillate scales, and pale greenish, elliptic perigynia changing to whitish and translucent at maturity. A sampling of perigynia, scales, and achenes are noted in Figure 4C and a typical inflorescence from a herbarium specimen is shown in Figure 5C.

Representative specimens. **COLORADO. Montrose Co.:** T47N, 20W, S13, La Sal Creek Cyn, 1.5 mi E of Utah-Colorado border. 16 Jun 1994, *Tuhy 3764* (COLO, UTC). **UTAH. Carbon Co.:** T14S R17E, S17, 3 Jun 2000, *Atwood 25772* (BRY). **Emery Co.:** jct. U-10 and old hwy to Moore, 8 Jun 1979, *White & Moore 85* (BRY); Big East Mt., 8 Aug 1977, *Lewis 5125* (BRY); San Rafael Swell, 5 Jun 1979, *Harris 326*; Straight Canyon, 13 Jun 1989, *Tuhy 3545*; San Rafael Reef, Cottonwood Wash, 6 May 2001, *Yeatts 4573 & Yeatts* (KHD). **Grand Co.:** Desolation Canyon, 9 May 1999, *Atwood & Evenden 24445* (BRY). **Juab Co.:** Mt. Nebo peak trail from Pole Canyon, 17 Jul 1980, *Collins & Harper 937* (BRY). **San Juan Co.:** ca. 1 mi upstream from jct. San Juan R. with Slickhorn Canyon, 1 Jun 2005, *Roth 1847* (NAVA); Two Mile Canyon, Lake Powell, 13 May 1983, *Welsh & Chatterley 22024* (BRY); John's Canyon bottom, 14 May 2000, *Clifford 216* (BRY); Ruin Canyon, 7 Jun 1976, *Shultz & Shultz 1900* (BRY). **Uintah Co.:** Firewater Canyon, Moonshine Canyon, 3 Jun 2000, *Atwood 25765* (BRY).

3. Carex holmgreniorum Reznicek & D.F. Murray, nom. et stat. nov. *Carex parryana* Dewey var. *brevisquama* F.J. Herm., Manual of the Carices of the Rocky Mountains and Colorado Basin 285. 1970. TYPE: UNITED STATES. UTAH: Cache Co.: ¼ mi S of Mendon, 6 Jun 1951, *A.H. Holmgren 8251* (HOLOTYPE: US photo!; ISOTYPES: BRY!, CAS!, MICH!, MO!, NY!, UTC!).

Carex aboriginum sensu K.K. Mackenzie. N. Amer. Fl. 18:364, 1935 non *Carex aboriginum* M.E. Jones, Bull. Montana Univ., Biol. Ser. 15:69. 1910.

Illustration.—Mackenzie, K.K. 1940. N. Amer. Caric. 2, pl. 421, as *C. aboriginum*.

Loosely cespitose from short, ascending rhizomes 2–3.5 mm thick, rhizomes ca. 0.5–2 cm long between shoots, rhizome scales brown, disintegrating into coarse fibers; culms 20–90 cm tall, stiffly erect, bluntly trigonous, very finely papillose, 0.6–1.1 mm wide immediately below the inflorescence; phyllopodic, cataphylls and basal sheaths brown, the youngest usually reddish-purple. Leaves ca. 6–12, essentially basal; blades 3.5–48 cm long, 1.5–4 mm wide, much shorter than culms, ±folded, margins and midrib smooth to finely antrorsely scabrous distally, ±smooth adaxially, papillose abaxially; leaf sheaths 1.5–15 cm long, glabrous, ventrally whitish or pale brown, hyaline, thin, concave at the apex; ligules ca. 0.8–5.5(–7.5) mm long, acute to rounded, slightly shorter than to longer than wide, the free portion whitish to pale brown. Inflorescences 3–9.5 cm long, with 3–5(–6) spikes, terminal staminate or sometimes gynaecandrous, laterals pistillate; upper lateral spikes ±overlapping, lower sometimes separate, lower two spikes 0.7–4.5 cm distant, lowermost ±sessile or on a ±smooth peduncle up to 14.2 mm long; lowest bracts ±bristle-like up to 7.5 cm long and 1.5 mm wide, sheathless, upper bracts abruptly reduced. Terminal spike (6.5–)11.5–27 mm long, pistillate portion (0–)2.5–10 mm long, 4.5–7.2 mm wide, ca. (0–)1–28-flowered, staminate portion 4.5–26.5 mm long, 1.8–3.5 mm wide, ca. 10–65-flowered, peduncle 1.8–38 mm long. Lateral spikes 4–22 mm long, 4–6.8 mm wide, short-cylindric, densely flowered with ca. 5–45 spreading-ascending perigynia. Staminate scales 2.5–4.1 mm long, 1.4–2.4 mm wide, ovate to obovate, reddish-brown with broad hyaline margins, apex obtuse to rounded, with a green, 1–3-nerved center. Pistillate scales 1.6–2.5 mm long, 1.5–2.2 mm wide, reddish-brown to reddish-purple, with broad hyaline margins, broadly ovate to ±circular, obtuse to rounded, green 1–3-nerved center rarely prolonged into a scabrous-ciliate apiculus or awn up to 0.4 mm long. Perigynia 2.5–3.3 mm long, 1.5–2.3 mm wide, rounded trigonous to plumply biconvex, broadly obovate, essentially filled by the achene, coriaceous, finely papillose distally, green to reddish-brown distally, greenish proximally, 2-nerved and sometimes with a few faint nerves on the faces, rounded-tapering to a ±sessile base, contracted into a well-defined cylindrical beak; beaks 0.25–0.5 mm long, finely papillose and sometimes setulose, green to brown, the apex ±erose to obscurely bidentulate with teeth up to 0.2 mm long. Achenes 1.7–2.4 mm long, 1.3–1.6 mm wide, concavely

tapering to a thick stipe 0.1–0.2 mm long, flattened-trigonous in cross section; convex sides narrowly elliptic to obovate, brown, smooth; apex usually apiculate with an apiculus up to 0.2 mm formed by the persistent style base; style deciduous; stigmas 3. Anthers 3, 1.7–3 mm long, with an apiculus ca. 0.1 mm long.

Etymology.—Carex holmgreniorum was chosen to honor Arthur H. Holmgren and Noel and Patricia Holmgren, who together have collected this species several times and whose scholarship has contributed so much to our knowledge of the Intermountain flora.

Alkaline seeps, adjacent to springs, riparian zones, moist meadows, pasture land, calcareous and often saline soils, with species such as *Juncus balticus* Willd., *Eleocharis rostellata* (Torr.) Torr., and *Schoenoplectus pungens* (Vahl) Palla. Elevation 1400–2000 m. UNITED STATES. Idaho, Nevada, Utah.

Some of the Utah localities of *C. parryana* mapped by Albee et al. (1988) presumably refer to this species.

Publication of *Carex parryana* var. *brevisquama* by Hermann (1968) lacked a citation of a type specimen as was required by the Code. Valid publication did not occur until 1970 when the name was again published by Hermann with *Holmgren 8251* as the type for the name (the holotype, and apparently the only sheet seen by Hermann at US, based on his annotation on the sheet). The epithet *brevisquama* was preoccupied at the rank of species by *C. brevisquama* Mack., and a new name must be used.

This is a distinctive species whose lack of recognition was due to its relative rarity and the confusion surrounding the misapplication of the name *C. aboriginum*. It is easily recognized by its combination of large pistillate lateral spikes, staminate or gynaecandrous terminal spike, broad achenes and perigynia, and pistillate scales distinctly shorter than the perigynia. It is an uncommon and local endemic of the northern Great Basin and western portion of the Colorado Plateau. A sampling of perigynia, scales, and achenes are noted in Figure 4A and a typical inflorescence from an herbarium specimen is shown in Figure 5A.

Representative specimens. **IDAHO. Caribou Co.:** Soda Springs, 9 Jun 1993, *Moseley 2620* (BRY). **NEVADA. Elko Co.:** Point Hot Springs, 4 air mi NE of Ruby Lake National Wildlife Headquarters, 20 Jun 1984, *Atwood 10222* (NY); Point Hot Springs, Ruby Lake, 20 Jun 1984, *Tiehm 8745* (BRY, MO). **Eureka Co.:** Hot Spring Hill, Antelope Valley, 8 Jun 2002, *Holmgren & Holmgren* (BRY); Pine valley, 9 Jun 2000, *Tiehm 13967* (BRY); Antelope Valley, Antelope Wash on N side Antelope Meadow, 5 Jun 2009, *Tiehm 15793 & Nachlinger* (NY). **Nye Co.:** Monitor Valley, Dianas Punch Bowl, S of Potts, 12 Jul 1984, *Tiehm 8941 & Ertter* (MO). **White Pine Co.:** Steptoe Valley, Duck Creek, 3.3 road mi W of Hwy 93 on road opposite Schellbourne Pass Road, 25 May 2007, *Tiehm 15380* (NY). **UTAH. Kane Co.:** Willis Creek, *Welsh & Atwood* 28487 (BRY); along Sheep Creek, on E side of bridge for County Road about 3 mi S of jct. with Cottonwood Canyon Road, ca. 5 air mi S of Cannonville, 4 Jul 2008, *Reznicek 11937* (KHD, MICH, NY, WTU); N side of Willis Creek Road about 3.7 mi W of jct. with Skutumpah Road, 4 Jul 2008, *Reznicek 11940* (MICH, NY, WTU); Wahweap, 20 Jun 1998, *Atwood & Welsh* 23932 (BRY). **Utah Co.:** American Fork, 4 Jul 1983, *Goodrich 18853* (BRY); Utah Lake near Saratoga, 23 May 1978, *Brotherson 2649* (BRY). **Wasatch Co.:** Charleston, 7 Jul 1984, *Goodrich 20831* (BRY).

4. Carex parryana Dewey, Amer. J. Sci. Arts 27:239; t. U, fig 65. 1835. TYPE: CANADA. [MANITOBA]: "Hudson Bay," *Dr. Richardson s.n.* (ISOTYPE: NY!).

Carex arctica Dewey, Amer. J. Sci. 27:239; t. V, fig. 66. 1835. TYPE: CANADA. [Saskatchewan]: Carleton House, *Dr. Richardson s.n.* (ISOTYPE: NY!).

Carex elrodii M.E. Jones, Bull. Montana Univ., Biol. Ser. 15:70; illustration pg. 19. 1910. TYPE: UNITED STATES. MONTANA. [Beaverhead Co.]: Monida, 7000 ft, Jul 8, 1909, *M.E. Jones s.n.* (ISOTYPES: CAS photo!, MO! NY 2 sheets!, US photo!).

Illustrations.—Mackenzie, K.K. 1940. N. Amer. Caric. II: pl. 412; Cronquist, A. et al. 1977. Intermountain Flora 6:131.

Colonial from short horizontal to ±ascending rhizomes 1.3–2.7 mm thick, rhizomes ca. 0.7–5.5 cm long between shoots, rhizome scales brown to reddish-purple, disintegrating into coarse fibers; culms 12–65(–70) cm tall, stiff, erect, trigonous, finely papillose with the angles sometimes slightly antrorsely scabrous, 0.5–1.4 mm wide immediately below the inflorescence; phyllopodic, cataphylls and basal sheaths brown, the youngest usually reddish-purple. Leaves ca. 6–12, essentially basal; blades 2–28 cm long, 1.4–4.1 mm wide, much shorter than culms, ±folded, margins and midrib smooth to papillose, becoming finely antrorsely scabrous distally, ±smooth adaxially, papillose abaxially; leaf sheaths 2–12.5 cm long, glabrous, ventrally whitish or pale brown, hyaline, thin, concave at the apex; ligules ca. 0.8–3.7 mm long, acute to obtuse, slightly shorter than to longer than wide, the free portion whitish to pale brown. Inflorescences 1.4–8 cm long, with (2–)3–5(–6) spikes, the terminal mostly gynaecandrous, less commonly pistillate, staminate, or rarely ±mixed, laterals pistillate; upper lateral spikes ±overlapping, lower sometimes separate, lower two spikes 0.3–5.2 cm distant,

lowermost ±sessile or on a papillose and ±scabrous-angled peduncle up to 28 mm long; lowest bracts ±bristle-like up to 5 cm long and 1.2 mm wide, sheathless, upper bracts abruptly reduced. Terminal spike 7.4–25(–30) mm long, pistillate portion (0–)2.1–17.5 mm long, 3–5.1 mm wide, ca. (0–)2–36-flowered, staminate portion (0–)2–24.8 mm long, 1.5–2.8 mm wide, ca. 3–70-flowered, peduncle 1.2–8.7 mm long. Lateral spikes 3–21.4 mm long, 2.5–3.6 mm wide, cylindric, densely flowered with ca. 3–45 spreading-ascending perigynia. Staminate scales 1.9–3 mm long, 1.2–2.2 mm wide, ovate to obovate, reddish-brown with broad hyaline margins, apex acute to rounded, the distal sometimes with the midvein prolonged into a short apiculus, with a green, 1–3-nerved center. Pistillate scales 2.1–2.7 mm long, 1.3–2 mm wide, reddish-brown to reddish-purple, with broad hyaline margins, broadly ovate, obtuse to rounded, green 1–3-nerved center rarely prolonged into a scabrous-ciliate apiculus or awn up to 0.4 mm long. Perigynia 2.1–2.8 mm long, 1.1–1.6 mm wide, flattened trigonous, the sides elliptic, essentially filled by the achene, coriaceous, finely papillose distally, green to reddish-brown distally, greenish proximally, 2-ribbed and sometimes with a few faint nerves on the faces, cuneately tapering to a ±sessile base, contracted into a short beak; beaks 0.1–0.3 mm long, finely papillose and sometimes setulose, green to brown, the apex ±erose to obscurely bidentulate with teeth up to 0.1 mm long. Achenes 1.3–1.6 mm long, 0.9–1.1 mm wide, ±cuneately tapering to a thick stipe ca. 0.1 mm long, flattened-trigonous in cross section; the convex sides elliptic to obovate, brown, smooth; the apex usually minutely apiculate with the persistent style base; style deciduous; stigmas 3. Anthers 3, 1.5–2.5(–2.7) mm long, including an apiculus ca. 0.1–0.2 mm long.

Moist alkaline margins of lakes and ponds, mudflats and alluvium, and similar conditions in forest openings. 200–2500 m. CANADA. Alberta, British Columbia, Manitoba, Ontario, Saskatchewan, Yukon. UNITED STATES. Alaska, Idaho, Montana, Wyoming.

Carex parryana and *C. arctica* were simultaneously published by Dewey. They were first united under the name *C. parryana* by Torrey (1836, pg. 426).

The location cited from Middlesex County, Ontario (*Oldham 10767*) is clearly an introduction into a saline highway interchange. In western Ontario in the Rainy River District, although also along a road, *C. parryana* co-occurs with other prairie species, and this is more likely a native occurrence, representing the eastern limit of its native range.

Representative specimens. **CANADA. ALBERTA:** W of Edmonton, 17 Sep 1872, *Macoun 31571* (CAN); Assiniboia, Milk R, 9 Jul 1895, *Macoun 10763* (GH, US); Banff, 15 Jul 1891, *Macoun 14049* (GH, NY, US); vic. Rosedale, 5 Jun 1915, *Moodie 943* (GH, NY, US); 10 mi S of Nordegg, 23 Jul 1964, *Smith 591* (MICH); headwaters of Saskatchewan and Athabasca Rivers, Kootany Plains, 12 Aug 1908, *Brown 1500* (NY). **BRITISH COLUMBIA:** ca. 3 mi N of Windermere, 30 Jul 1953, *Calder & Savile 11198* (NY); Eight mi S of 83 Mile House along main Hwy between Williams Lake and Clinton, 24 Jun 1956, *Calder, Parmelee & Taylor 17865* (COLO, MICH, NY, US); 3 mi N of Jesmond, 12 Jul 1956, *Calder, Parmelee & Taylor 18764* (ALA, DAO); six mi on road to Bridge Lake from 70 Mile House, *Calder, Parmelee & Taylor 18837* (MICH); Kamloops, 16 Jun 1889, *Macoun s.n.* (MO); Kamloops, 18 Jun 1889, *Macoun 31573* (CAN). **MANITOBA:** Gypsumville, 140 mi NW of Winnipeg, 13 Jul 1951, *Scoggan 9466* (CAN, WIN); Oak Point, 60 mi NW of Winnipeg, 16 Jul 1951, *Scoggan 9588* (CAN, WIN); Township 3, Range 4, on road between sections 11 and 14, 21 Aug 1996, *Oldham 19367 & Punter* (MICH). **ONTARIO. Middlesex Co.:** North Dorchester Twp., 4.6 km SE of Dorchester Post Office, Hwy 401 at Hwy 73 interchange, 19 May 1990, *Oldham 10767* (MICH). **Rainy River District:** Hwy 11 roadside ca. 2 km W of Seine River Bridge, 18 Jul 1997, *Oldham 20222* (MICH). **SASKATCHEWAN:** Sifton, 27 Jun 1911, *Clokey 663* (MO). Saskatoon, 18 Jul 1934, *Fraser 31* (MICH); One half mi W of Peesane, 7 Jul 1939, *Fraser 232* (ALA, DAO); NE of Strawberry Lake, 6 mi N and 1 mi E of Odessa, 21 Jun 1979, *Ledingham 6094*; 2½ mi E and 3½ mi S of Quantock, 2 Jun 1981, *Ledingham 7036*. **YUKON.** Vicinity of the mouth of Slim's R., Kluane L., approx. Lat. 60°59'N Long. 138°33'W, 11 Jul 1944, *Raup & Raup 12423* (MICH); S end of Kluane L., 6 Aug 1966, *Murray 668* (ALA, NY); Alsek R. valley near mi 1021, Alaska Hwy, 24 Jun 1944, *Raup & Raup 11916* (ALA, GH, MICH, NY); Mi 984.5, Alaska Hwy., 14 Jul 1959, *Taylor 4100* (ALA, DAO), Donjek R crossing at Alaska Hwy., 8 Aug 2003, *Bennett, Elven & Solstad 03/01/0167* (ALA, O). **UNITED STATES. ALASKA:** Anchorage Quad.: Eklutna, 7 Jul 1947, *Dutilly, Lepage & O'Neill 20709* (US); McCarthy Quad.: White R. valley at Alaska Hwy., 5 Jun 2003, *Bennett & Loomis 03-228* (ALA); Chitina R. at terminus Barnard Glacier, 5 Aug 1996, *Duffy & Barnes 96-012* (ALA). **IDAHO. Custer Co.:** 2 mi S of Dickey, 14 Jul 1941, *Cronquist 3106* (GH, MO); Thousand Springs Valley, ca. 6 mi S of Willow Creek Summit, 22 Jun 1983, *Henderson & Cholewa 6601* (NY). **MONTANA. Beaverhead Co.:** Monida, 14 Jul 1908, *Jones s.n.* (POM); tributary stream just N of Simpson Creek, 10 Aug 1997, *Lesica 7503* (ALA); Blacktail Range, ridge just S of Ashbaugh Peak, T9S R8W, S32, 12 Jul 2003, *Lesica 8705* (MICH); ca. 5 mi NE of Lima, 30 Jul 1997, *Lesica 7486* (NY); Nicholia Creek, E of confluence with Rock Creek, 12 Jul 1993, *Lesica 6086* (NY). **Carbon Co.:** Sage Creek ca. 1 mi N of Warren, 27 Jun 1998 *Lesica 7614* (NY); Lloyd's Cabin T8S R29E S28, 9 Jun 1983, *Lichvar 5919 (NY).* **Carter Co.:** Headwaters of a Hammond Creek tributary, T1S R62E, Sec. 4 NE ¼, 9 Jun 1997, *Heidel & Cooper 1550* (MICH). **Glacier Co.:** Blackfoot, 24 Jul 1894, *Williams 451* (MONT, RM). **Madison Co.:** along the streams below Wolf Creek Hot Spring S of Cameron, 19 Jul 1990, *Lesica 5184* (MICH); small thermal stream flowing from Trudeau Lake, T7S R4W S7, 28 Jul 1997, *Lesica 7476* (NY); ca. 2 mi SSE of Melrose,

T3S, R9W, Sec. 1 SW ¼, 19 Aug 1997, *Heidel 1612* (MICH). **Powell Co.:** ¼ mi E of Kleinschmidt Lake, T14N R11W S18, 1 Jul 1993, *Lesica 6027* (NY). **Teton Co.:** North Fork Willow Creek, ca. ½ mi SE of Duhr House, 25 mi W of Choteau, 23 Jul 1982, *Lesica 2273* (NY). **Wheatland Co.:** Galloway Creek, ca. 10 mi NE of Harlowton, 26 Jul 1988, *Lesica 4693* (NY). **WYOMING. Sublette Co.:** Jackamore Creek, 21 Jun 1901, *Merrill & Wilcox 609* (GH, NY)

5. Carex hallii Olney in Hayden, Rep. U.S. Geol. Surv. Terr. 5:496. 1872 (non L.H. Bailey 1886). TYPE: UNITED STATES. Colorado: *Hall & Harbour 617* (HOLOTYPE: BRU!; ISOTYPES: DUKE fide Weber 1997, n.v., GH!, ISC fide Weber 1997, n.v., NY!, US!). *Carex parryana* Dewey var. *unica* L.H. Bailey, Mem. Torrey Bot. Club 1:54. 1889; *Carex parryana* Dewey var. *hallii* (Olney) Rydb., Mem. New York Bot. Gard. 1:74. 1900 (nom. superfl. and illegit.); *Carex parryana* Dewey subsp. *hallii* (Olney) D.F. Murray, Brittonia 21:71. 1969.

Illustration.—Mackenzie, K.K. 1940. N. Amer. Caric. 2, pl. 411.

Colonial from ±elongate rhizomes 1.2–2.3 mm thick, rhizomes ca. 0.5–16 cm long between shoots, rhizome scales brown, disintegrating into greyish fibers; culms (6–)9–38 cm, stiff, erect, trigonous, the angles sometimes antrorsely scabrous, papillose, 0.4–1.1 mm wide immediately below the inflorescence; phyllopodic, cataphylls and basal sheaths brown, the youngest often reddish-purple tinted. Leaves 4–10, essentially basal; blades 1.8–18(–22) cm long, 1.6–4.3 mm wide, much shorter than culms, ±folded, margins and midrib smooth to finely antrorsely scabrous distally, ±smooth adaxially, papillose abaxially; leaf sheaths 11–7.5 cm long, glabrous, ventrally whitish or pale brown, hyaline, thin, shallowly concave at the apex; ligules 0.5–2.7 mm long, obtuse to rounded, shorter than wide, free portion whitish to pale brown. Inflorescences 1.2–4.5 cm long, with 1–3(–5) spikes, terminal spike staminate (with sometimes 1–3(–8) pistillate flowers at base or apex) or pistillate, rarely mixed, the laterals pistillate; lateral spikes overlapping or separate, the lower two spikes 0.3–0.7(–1.8) cm distant, the lowermost sessile or on a papillose peduncle up to 8.2 mm long; lowest bracts ±bristle-like up to 3.2(–6) cm long, 0.3–0.7(–1.8) mm wide, sheathless or nearly so, upper bracts abruptly reduced. Terminal spike 12–33 mm long; 20–75-flowered and 3.2–5 mm wide when pistillate, 35–90-flowered and 2.2–3.8 mm wide when wholly or largely staminate, the peduncle 2–12 mm long (if lateral spikes present). Lateral spikes, if present, 3–14 mm long, 2.4–3.5 mm wide, cylindric, densely flowered with ca. 3–30 ascending perigynia. Staminate scales 2.6–3.6 mm long, 1.4–2.2 mm wide, ovate, reddish-brown to pale purple with narrow hyaline margins, especially distally, apex broadly acute to rounded, the green, 1–3-nerved center sometimes prolonged into a ±short apiculus on the distal scales. Pistillate scales 1.8–3(–3.2) mm long, 1.4–1.9 mm wide, reddish-brown to reddish-purple, with broad hyaline margins, ovate to ±oblong, broadly to rounded, the green 1–3-nerved center sometimes prolonged into a scabrous-ciliate apiculus or broad awn up to 0.5 mm long. Perigynia 1.7–2.4 mm long, 0.9–1.8 mm wide, ±flattened-trigonous in cross-section, ±obovate, tightly wrapping the achene, ±coriaceous, papillose distally, green to brown, 2-ribbed and frequently with a few faint nerves on the faces, tapering to a short stipitate base, contracted into a short cylindrical beak; beaks 0.2–0.4 mm long, papillose and sometimes setulose, green to purplish-brown, apex bidentulate with teeth up to 0.1 mm long. Achenes 1.3–1.6 mm long, 0.8–1.2 mm wide, cuneately to slightly concavely tapering to the base, flattened-trigonous in cross section; the convex sides obovate, brown, smooth; apex with a tiny apiculus up to 0.2 mm formed by the persistent style base; style deciduous; stigmas 3. Anthers 3, (1.5–)2–3.6 mm long, with a short apiculus ca. 0.1 mm long.

Moist, frequently alkaline, soils of fens, meadows, and prairies. Elevation 200–3400 m. CANADA. Manitoba, Saskatchewan. UNITED STATES. Colorado, Minnesota, Nebraska, South Dakota, North Dakota, Wyoming.

Carex hallii was published by Olney, who contributed the treatment of *Carex* to T. C. Porter's Catalogue of plants (pp. 477–498) in the Preliminary Report of the United States Geological Survey of Montana and Portions of Adjacent Territories by Hayden (1872). In what is otherwise a list of species, Olney included text bounded by quotes consisting of a description, etymology of the name, and citation of a specimen, *Hall & Harbour 617*. In addition to this protologue, but outside of the quotes, was added the location "Pleasant Valley," representing a specimen also thought (by Porter?) to be *C. hallii*. This "Pleasant Valley" specimen has been treated as the type, starting with Mackenzie's (1935) citation of the type locality as "Pleasant Valley, Idaho" and also by Murray (1969) who followed Mackenzie and noted "There is a specimen from the Rocky Mountains, Jun 1871, *Hayden s.n.* (NY!). This should be the lectotype if no better Hayden material can be found." We argue

here that Olney's *C. hallii* was clearly based on *Hall & Harbour 617* in Olney's herbarium (BRU!), which was cited inside the quotes, and clearly fits the protologue, which calls for a specimen that "... resembles *C. scirpoidea* when the latter has a second small spike. ..." This specimen was most likely collected in South Park, Colorado (Weber 1997). The Hayden specimen from Pleasant Valley is in conflict with the protologue, having two substantial lateral spikes, thus not at all like "... *C. scirpoidea* when the latter has a second small spike ..." and is in fact *C. idahoa*. Pleasant Valley is located in the northeast corner of Yellowstone National Park in present day Park Co., Wyoming, near the Montana Border at 44°55'45"N, 110°25'17"W (J. Reveal, pers. comm.).

Carex hallii exhibits an unusual sex distribution in the inflorescences. Terminal spikes are usually either staminate or pistillate, with rarely one or a few pistillate flowers at the base or apex of the predominantly staminate spikes, and occasionally a very few staminate flowers, often scattered, in the pistillate spikes. However, lateral spikes, if present, are always pistillate regardless of the sex of the terminal spike. This feature appears to be distributed clonally; observations of several populations in Colorado determined that clones have either predominately staminate or predominately pistillate terminal spikes.

Carex hallii reports from California, as *C. parryana* var. *hallii* (e.g., Mastrogiuseppe 1993), were redetermined as *C. idahoa*. See the discussion under *C. idahoa*.

Representative specimens. **CANADA. MANITOBA:** Brandon, 24 Jun 1951, *Stevenson 374* (ALA); Oak R. at Lothair, 21 Jun 1906, *Macoun & Herriot 72728* (CAN, NY, US); Pierson Wildlife Management Area, 7 mi SW of Pierson, 29 May 1975, *Knapton 37* (WIN). **SASKATCHEWAN:** Moose Mt., 7 mi S of Kennedy, 13 Jul 1951, *Boivin & Dore 7798* (DAO). **UNITED STATES. COLORADO. Chaffee Co.:** Monarch Pass, 20 mi W of Salida, 22 Jun 1926, *Erlanson 2020* (MICH). **Clear Creek Co.:** Silver Plume, 3 Jul 1922, *Ehlers 132* (MICH, NY). **El Paso Co.:** Ruxton Canyon, Pike's Peak, 30 Jul 1922, *Ehlers 609* (MICH, NY); 4½ mi E of Falcon, 22 Aug 1946, *Livingston 1430* (COLO). **Gunnison Co.:** Gunnison Basin, lower Quartz Creek, 7 mi N of Parlin, 9 Jul 1994, *Weber & Wittmann 19051* (COLO). **Lake Co.:** Lake Creek, 17 Jul 1919, *Clokey 3332* (ALA, COLO, GH, LCU, MICH, MO, NY, RM, US, UTC); Twin Lakes, 4 Jul 1919, *Clokey 3333* (ALA, GH, MICH, MO, NY, RM, US, UTC). **Larimer Co.:** Fall River Valley, Horseshoe Park, Rocky Mt. Nat. Park, 12 Jun 1961, *Kornas & Willard s.n.* (COLO); Soapstone Prairie, City of Fort Collins Natural Area, 25 mi N of Fort Collins just S of Wyoming state line, 23 Jun 2011, *Wingate 9052* (KDH, MICH). **Park Co.:** South Park, 1873, *Wolfe s.n.*, (MICH, NY); South Park, 10 Aug 1927, *Hanson 2687* (MO); South Park at Jefferson, 17 Aug 1960, *Weber, Porsild & Holmen 11,103* (COLO); Geneva Creek, T6S R75W, 9 Aug 1970, *Gierisch s.n.* (COLO); Slater Ditch, Elkhorn Rd. ca. 1½ mi SE of Cline Reservoir, 29 Jun 1985, *Neely 2998* (COLO); Antero-Salt Creek Natural Area, ca. 17 mi S of Fairplay and ca. 1 mi W of US285 off Pony Park Road, 3 Aug 2011, *Wingate 9208 Regensberg & Clark* (KHD, MICH); E side of Four Mile Creek Road ca.4.5 air mi SW of Fairplay, 16 Aug 2012, *Reznicek 12143* (KHD, MICH); W side of South Park, 5 mi S of Fairplay, 23 Aug 1997, *Weber & Wittmann 19254* (COLO); Lost Park Road (CR 56), Johnson Gulch tributary of Rock Creek, 18 Aug 2012, *Reznicek 12147* (KHD, MICH, NY, WTU); along County Road 62, paralleling Geneva Creek, ca. 4.5 air mi NW of Grant (jct. US Hwy 285), opposite road from Burning Bear Campground, 18 Aug 2012, *Reznicek 12149* (MICH). **Summit Co.:** Breckenridge, Aug 1901, *Mackenzie 382* (NY). **NEBRASKA. Kearney Co.:** Minden, 26 May 1898, *Hapeman s.n.* (MICH, MO, NY), 9 May 1913, (MO); 23 May 1927 (ALA, GH, NY, RM, US); Lexington, 16 Jun 1929, *Hapeman s.n.* (UTC). **NORTH DAKOTA. Benson Co.:** Leeds, 10 & 19 Jun 1905, *Lunell s.n.* (MICH, NY). **WYOMING:** Laramie Plains, 20 Jul 1884, *Sheldon* (MICH). **Albany Co.:** Laramie, 19 Jun 1894, *Nelson 274a* (NY); 31 May 1897, *Nelson 2943* (MICH). **Carbon Co.:** Big Creek, 10 Jul 1901, *Tweedy 4325* (NY, US). **Goshen Co.:** near North Platte River at Nebraska state line, 6 Jun 1964, *Johnson 412* (MICH). **Laramie Co.:** Pine Bluffs, 15 May 1897, *Nelson 2901* (NY); Centennial, 26 Jul 1900, *Nelson 7682* (NY). **Platte Co.:** Cold Springs, 13 Jul 1894, *Nelson 447* (MO); Battle Lake, 16 Aug 1897, *Nelson 4020* (UTC).

6. Carex idahoa L.H. Bailey, Bot. Gaz. 21:5–6. 1896. TYPE: UNITED STATES. IDAHO: Beaver Canyon, *P.A. Rydberg 2339*. (Of two duplicate sheets at US!, 235569 is here designated LECTOTYPE; ISOLECTOTYPE US! 235568). *Carex parryana* Dewey subsp. *idahoa* (L.H. Bailey) D.F. Murray, Brittonia 21:73. 1969.

Carex parryana Dewey var. *statoni* M.E. Jones, Bull. Montana Univ., Biol. Ser. 15:72; illustration pg. 71. 1910. TYPE: UNITED STATES. MONTANA. [Powell Co.]: Ryan's, Deer Lodge Valley, 5300 ft, *M.E. Jones s.n.*, Aug 3, 1905. (HOLOTYPE: Herb. M.E. Jones, POM [photo!]).

Illustration.—Mackenzie, K.K. 1940. N. Amer. Caric. 2, pl. 410.

Loosely cespitose to slightly colonial from ±elongate rhizomes 1.7–2.7 mm wide, rhizomes ca. 0.5–10 cm long between shoots, rhizome scales pale brown, rapidly disintegrating into fibers; culms (6–)10–48 cm, ±erect, trigonous, smooth to finely papillose or somewhat scabrous-angled, 0.6–1.1 mm wide immediately below the inflorescence; phyllopodic, cataphylls and basal sheaths pale to dark brown, the youngest tinged red-dish-purple. Leaves 4–12, essentially basal; blades 2.5–22 cm long, 1.3–5.5 mm wide, shorter than culms, ±folded, the margins and midrib smooth to finely antrorsely scabrous distally, ±smooth adaxially, ±papillose abaxially, especially distally; leaf sheaths ca. 2–12.5 cm long, glabrous, ventrally whitish or pale brown, sometimes finely brown streaked, hyaline, thin, concave at the apex; ligules ca. 0.6–1.5 mm long, obtuse to rounded,

shorter than wide, free portion whitish to pale brown. Culms apparently unisexual (and plants presumably dioecious, but field observations unavailable); Pistillate inflorescences 1.6–5.3 cm long, with 1–3(–4) spikes; lateral spikes, if present, ±overlapping, the lower two spikes 0.6–1.7 cm distant, the lowermost ±sessile or on a ±papillose and scabrous-angled peduncle up to 8.5 mm long; lowermost bracts scale-like to bristle-like, blades up to 1.8 cm long and 1.6 mm wide, sheathless, upper bracts abruptly reduced. Terminal spike 12.5–34 mm long, (4.5–)5.5–9 mm wide, ca. 30–60-flowered. Lateral spikes 5.5–17.5 mm long, ca. 3–5.5 mm wide, cylindric, ca. 8–28-flowered. Staminate inflorescences poorly known, ca. 1.6–3.7 mm long, with 1–3 spikes; lateral spikes, if present, ±overlapping, the lower two spikes ca. 0.4–1.3 cm distant, the lowermost ±sessile; lowermost bracts scale-like to bristle-like, blades observed up to l.1 cm long and 0.8 mm wide, sheathless, upper bracts abruptly reduced. Terminal spike ca. 14–22.5 mm long, ca. 4–4.5 mm wide, ca. 40–60-flowered. Lateral spikes ca. 4.5–15.5 mm long, ca. 1.5–3 mm wide, cylindric, ca. 8–25-flowered. Staminate scales 3.2–5.1 mm long, 1.9–3.2 mm wide, ovate, dark reddish-brown or purple-brown with broad hyaline margins and green 3-nerved center, the apex obtuse to acute. Pistillate scales (2.1–)2.4–4.6 mm long, 1.2–2 mm wide, dark reddish-brown to purple-black, with at most narrow hyaline margins, broadly to narrowly ovate to elliptic, obtuse and cuspidate to acuminate, with a green to reddish purple 1-nerved center. Perigynia 2.1–2.7 mm long, 1.3–2 mm wide, ±strongly flattened-trigonous in cross-section, broadly elliptic to obovate, ±coriaceous, somewhat papillose distally, green to brown, often reddish-purple tinged on and near the base of the beak, 2-ribbed, tapering to a short stipitate base, ±abruptly contracted into a cylindrical beak; beaks 0.2–0.5 mm long, smooth to somewhat papillose, sometimes slightly setulose, green to purplish-brown, apex ±erose to bidentulate with teeth up to 0.1 mm long. Achenes 1.5–1.8 mm long, 0.9–1.2 mm wide, cuneately tapering to a short stipe ca. 0.1 mm long, trigonous in cross section; the convex sides obovate, brown, smooth; apex apiculate with an apiculus up to 0.1 mm formed by the persistent style base; the style deciduous; stigmas 3. Anthers 3, ca. 2.8–4.5 mm long, with a short, triangular apiculus ca. 0.1 mm long.

Moist margins of seasonally moist calcareous meadows where the surrounding vegetation is steppe. Elevation 1400–3200 m. UNITED STATES. California, Idaho, Montana, Oregon, Utah, Wyoming.

We have not seen specimens of *Carex idahoa* from Oregon, but the photographs in Wilson et al. (2008) are convincing.

In order to be consistent with the International Code of Botanical Nomenclature, Boivin (1979, p. 87) considered the correct spelling of the epithet to be *idahoana*, the adjectival form of Idaho. While *idahoana* may be more correct linguistically, the spelling *idahoa* is not a correctable error covered by the Code, and we retain Bailey's original spelling.

The distinctive dark color of the scales in *Carex idahoa* fades late in the season to a dull brown (though still darker than *C. hallii* or *C. parryana*), and then it may resemble a robust *C. hallii* in having the lateral spikes small, with the terminal spike (1.2–)1.5–3.3 times as long as the longest lateral or more, and also in having the terminal spike unisexual. However, *C. idahoa* mostly (about ⅔ of the time in a sample of 50 inflorescences) has 2 lateral spikes; only about 25% of plants have a single lateral spike and only about 8% are unispicate. This is different from *C. hallii* where 87% of the inflorescences have only one lateral spike or are unispicate. Furthermore, though male inflorescences are poorly represented in herbaria, *C. idahoa* appears to be dioecious, with both the lateral spikes and the terminal spike male, while in *C. hallii*, the lateral spikes are female, regardless of the sex of the terminal spike.

California plants noted as *Carex parryana* var. *hallii* (Mastrogiuseppe 1993) are here referred to *C. idahoa*, and were treated as such in the recent revision of the California flora (Zika et al. 2012). However, although they are similar in overall appearance and in being dioecious, they tend to be smaller than Rocky Mountain plants, with somewhat narrower spikes (the widest terminal spikes ca. 4.5–5.7 mm wide), and the pistillate scales, though dark and longer than the perigynia, are also shorter (the longest 2.2–2.5 mm long), and blunter than typical for Rocky Mountain plants. More collections and study are needed here. With a larger sample, also including Oregon collections, to provide a clearer view of their variability, it may be that the California plants will prove worthy of formal recognition.

Representative specimens. **UNITED STATES. CALIFORNIA. Mono Co.:** White Mts., Spring 75 m W of the dry bed of Poison Creek 0.25 km S of confluence with Cottonwood Creek, Cottonwood Basin, 4.3 air mi ENE of Sheet Mt., 7 Aug 2012, *Zika et al. 26045* (ALA, MICH); White Mts., Granite Meadow, Cottonwood Basin, 4.3 air mi ENE of Sheet Mt., 7 Aug 2012, *Zika et al. 26047* (ALA, MICH); White Mts., 0.65 mi SW of Station Peak at Deep Springs, 13 Aug 1983, *Morefield JDM-1698* (NY); White Mts., N Fork Cottonwood Creek, 1.8 mi NE of Eva Belle Mine, 12 Jul 1987, *Morefield et al. 4611* (NY). **IDAHO. Bannock Co.:** Blackfoot R, 2–11 Sep 1913, *W.W. Eggleston 9985* (US). **Bonneville Co.:** Gray's Lake, 47 mi SE Idaho Falls, 19 Jul 1945, *Christ & Ward 14999* (NY). **Nez Perce Co.:** Beaver Canyon Meadow, T35N R4W S10, Aug 1895, *Shear 5391* (NY, RM). **MONTANA. Beaverhead Co.:** Monida, 8 Jul 1909, *Jones s.n.* (MICH, MO, NY); 4 mi N of Jackson, 8 Sep 1955, *Hermann 12485* (MICH); W of Upper Red Rock Lake, 10 Sep 1955, *Hermann 12490* (MICH); Beaverhead Mtns, along Cottonwood Creek ca. 1 mi W of Lower Harkness Lake, 31 Jul 1990, *Lesica 5208* (MICH); E Morrison Lake T14S R12W S23, 29 Jul 1989, *Lesica & Cooper 4979* (NY); Tendoy Mtns, along Sourdough Creek, 9 Jul 1993, *Lesica 6066* (MICH); Tendoy Mtns, along Nicholia Creek just E of the confluence with Rock Creek, 12 Jul 1993, *Lesica 6088* (MICH); ca. 1 mi N of Box Spring, 20 Jun 1995, *Lesica 6762* (MICH); along a small spring 1 mi S of Basin Creek, 29 Jun 1995, *Lesica 6792* (MICH); hills W of Sand Creek, 1 Aug 1997, *Lesica 7493* (ALA); Hildreth Ranch, 30 Jul 1997, *Lesica 7484* (ALA); head of Clover Creek, T13S R6W S1, 1 Aug 1997, *Lesica 7495* (NY); along Coyote Creek, Coyote Lake, T15S R11W S7, 10 Aug 1997, *Lesica 7502* (NY); along Taylor Creek just below Taylor Mine, T7S R11W S18, 29 Jul 1997, *Lesica 7479* (NY). **Custer Co.:** 18 mi SW of Mackay, 22 Jul 1965, *Hermann 20106* (MICH, NY). **Gallatin Co.:** Spanish Basin, 28 Jun 1897, *Rydberg & Bessey 3813* (NY); Mystic Lake, 25 Jul, *Shear 485* (NY). **Madison Co.:** Grassy Lake, 27 Jul 1997, *P. Lesica 7470* (ALA), Forks of the Madison, 26 Jul 1897, *Rydberg & Bessey 3762* (NY). **Powell Co.:** Deer Lodge, *Rydberg 2128* (NY, US). **Silver Bow Co.:** Butte Highlands, Moose Creek, 22 Jul 1981, *Lackschewitz 9728* (ALA, NY); T3N R9W S13, 8 Jul 1895, *Shear 5462* (NY). **UTAH. Wasatch Co.:** T4S R10W S6 E½, SE of Heber City, Strawberry Valley, Windy Ridge, 1 Jul 1983, *Goodrich 18815* (NY). **WYOMING. Park Co.:** Pleasant Valley, Jun 1871, *Hayden s.n.* (NY). **Teton Co.:** Expedition of Capt. W.F. Raynolds to the head waters of the Missouri and Yellowstone rivers, Gros Ventre Pass, 6,500 ft, 18 Jun 1860, *Hayden, s.n.* (BRU).

ACKNOWLEDGMENTS

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BOOK REVIEW

CARMINE STAHL AND RIA MCELVANEY. 2012. **Trees of Texas: An Easy Guide to Leaf Identification. 2nd Edition.** (ISBN: 978-1-60344-515-3, flexbound). Texas A&M University Press, John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77845-4354, U.S.A. (**Orders:** www.tamupress.com, 1-800-826-8911). $24.95, 338 pp., 18 color photos, 270 b/w photos, map, bib., index, 8 ½" × 11".

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detail is lost including fine distinctions of color in leaves, flowers, and bark. Presumably, this choice was made to keep costs in line, but the lack of color does significantly lower the value of the illustrations for identification purposes.

The single greatest lack, however, are the fine details that aid in distinguishing among trees with broadly similar leaves (i.e., leaf margins, glands, and venation patterns, among others). Leaf surface characteristics such as waxy cuticles, hairs, or scales are also missing from the illustrations. A simple close-up of key ancillary characteristics would have significantly improved the certainty of identifications made with this guide. Likewise, floral and fruit characteristics are presented haphazardly. Some illustrations include fruits, some include flowers, and some have neither. While these details may not be strictly necessary for the identification of a tree species, they are an essential part of knowing and understanding what makes a species unique—and what each species has in common with its relatives.

The best guidebooks intended for amateur audiences offer both user-friendly means of identification along with a path to a deeper understanding of the philosophy underpinning how and why species are named and classified as they are. There is a reason, after all, why the foliar characteristics used in *Trees of Texas* are not used in determining plant families. That said, *Trees of Texas* does achieve its goals in making tree identification much easier while providing interesting and useful tidbits of historical and ethnobotanical information.

—*Brian Witte, Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

NEW COMBINATIONS IN *CAREX KELLOGGII* (CYPERACEAE)

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ABSTRACT

Carex interrupta Boeck. var. *impressa* L.H. Bailey and *C. vulgaris* Fr. var. *limnophila* Holm are transferred to *C. kelloggii* W. Boott to be consistent with recent molecular phylogenetic studies.

RESUMEN

Carex interrupta Boeck. var. *impressa* L.H. Bailey y *C. vulgaris* Fr. var. *limnophila* Holm se transfieren a *C. kelloggii* W. Boott para ser consistentes con estudios filogenéticos moleculares recientes.

INTRODUCTION

Recent molecular phylogenetic work on *Carex lenticularis* Michx., *C. aquatilis* L., and related species (Dragon & Barrington 2009) resulted in the recommendation that western species of the *Carex lenticularis* complex are sufficiently distinct from eastern *C. lenticularis* to warrant recognition at the species level, as *C. kelloggii* W. Boott. Although the three varieties of this western taxon are not differentiated at the DNA sequences used during this study, they can be distinguished morphologically (Standley 1985; Dragon & Barrington 2009). However, two of the taxa have not been published as varieties of *C. kelloggii*. In preparation for publishing a second edition of our field guide to sedges of Oregon and Washington (Wilson et al. 2008), we are publishing those combinations now.

Carex kelloggii W. Boott var. **impressa** (L.H. Bailey) B.L. Wilson & N. Otting, comb. nov. *Carex interrupta* Boeck. var. *impressa* L.H. Bailey, Mem. Torrey Bot. Club 1(1):18. 1889. *Carex lenticularis* Michx. var. *impressa* (L.H. Bailey) L.A. Standley, Syst. Bot. Monogr. 7:65. 1985. TYPE: U.S.A. CALIFORNIA: *Kellogg s.n.* (LECTOTYPE, selected by Standley 1985: BH).

Carex kelloggii W. Boott var. **limnophila** (Holm) B.L. Wilson & R.E. Brainerd, comb. nov. *Carex vulgaris* Fr. var. *limnophila* Holm, Amer. J. Sci. ser. 4, 17(100):307–308. 1904. *Carex lenticularis* Michx. var. *limnophila* (Holm) Cronquist, Vascular Plants of the Pacific Northwest 1:279. 1969. TYPE: U.S.A. ST. PAUL ISLAND: Bering Sea, *Macoun 16613* (LECTOTYPE, selected by Cronquist 1969: LCU; ISOLECTOTYPE: GH).

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BOOK REVIEW

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The best guidebooks intended for amateur audiences offer both user-friendly means of identification along with a path to a deeper understanding of the philosophy underpinning how and why species are named and classified as they are. There is a reason, after all, why the foliar characteristics used in *Trees of Texas* are not used in determining plant families. That said, *Trees of Texas* does achieve its goals in making tree identification much easier while providing interesting and useful tidbits of historical and ethnobotanical information.

—Brian Witte, Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.

A REVISION OF *CORDIA* SECTION *GERASCANTHUS* (BORAGINALES: CORDIACEAE)

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ABSTRACT

A taxonomic revision is provided for *Cordia* section *Gerascanthus* and 23 species are recognized. They are characterized by flowers with tubular, ribbed calyces, marcescent corollas that persist and surround the developing fruits, aiding in their wind dispersal, and single-seeded ellipsoid fruits with a fibrous wall. All of the species are restricted to the Neotropics. Thirteen occur in Mexico, and the remainder are scattered throughout Central America, the West Indies, and South America; however, there is no secondary center of diversity. Classification of the section and its morphology are reviewed, and a key and descriptions are provided for all species along with notes on their distributions and conservation status.

RESUMEN

Se hace una revisión taxonómica de *Cordia* section *Gerascanthus* y se reconocen 23 especies. Se caracterizan por sus flores con cálices tubulares provistos de costillas, corolas marcescentes que persisten y rodean los frutos en desarrollados, ayudando en su dispersión anemófila, y frutos elipsoides uniseminados -provistos de una envuelta fibrosa. Todas las especies están restringidas a la región Neotropical. Trece ocurren en México, y las restantes están dispersas por toda América Central, las Indias Occidentales, y Sur América; sin embargo, no hay centro secundario de diversidad. Se revisa la clasificación de la sección y su morfología, y se aporta una clave y descripciones de todas las especies junto con notas de sus distribuciones y status de conservación.

INTRODUCTION

Cordia has historically been defined in a broad sense (e.g., Johnston 1930; Miller 2001) with estimates for the number of species ranging from 250 (Airy Shaw 1973) to 350 (Miller 2001). However, in the last two decades, a number of advances in our understanding of its relationships with other related genera, relationships within the genus, and floristic studies of the constituent species have added considerably to what we understand. Several phylogenetic studies have shown that Boraginaceae, which have historically been considered to comprise four very distinct and morphologically different subfamilies: Cordioideae, Ehretioideae, Heliotropioideae, Boraginoideae (Johnston 1951), were more complicated (Gottschling & Hilger 2001; Gottschling et al. 2005; Moore & Janse 2006; Nazaire & Hufford 2012; Weigend et al. submitted). Several other families, or enigmatic genera, including Hydrophyllaceae, Lennoaceae, and the African genera *Codon*, *Hoplestigma*, and *Wellstedtia* were all embedded within the Boraginaceae, but all of the original four subfamilies were proven to be monophyletic, although a few genera had historically been placed in the wrong group (Gottschling et al. 2005). It is now clear that *Saccellium* and *Coldenia*, both long considered allied with *Ehretia*, are more closely related to *Cordia*, the former included within it and the later sister to *Cordia* and *Varronia* (Gottschling et al. 2005). This has lead to the recognition of a broadly defined Boraginales (Gottschling et al. 2005), including each of the four traditional subfamilies elevated to familial status, Cordiaceae, Ehretiaceae, Heliotropiaceae, and Boraginaceae, and also inclusion of the Hydrophyllaceae, Lennoaceae, Hoplestigmataceae, Wellstedtiaceae, and newly described Codonaceae (Weigend & Hilger 2010).

For the Cordiaceae, the studies of Gottschling et al. (2005) elucidated that the Old World procumbent annual herb *Coldenia procumbens* was sister to all of the other woody members of Cordiaceae and then *Cordia* section *Varronia* was sister to all of the rest of *Cordia* and the three small genera that had been recognized because of unique, unusual fruits, which all have large accrescent calyces (*Auxemma* Miers, *Patagonula* L., and *Saccellium* Bonpl.), were all embedded in *Cordia* and allied with the species of *Cordia* section *Cordia*. Based on this evidence, Miller and Gottschling (2007) segregated *Varronia* and restricted *Cordia* to the members of sec-

tions *Cordia*, *Gerascanthus*, *Myxa*, and *Superbiflorae*, though the molecular data clearly show that the Old World and New World species of section *Myxa* are distinct clades, even though they appear morphologically similar. Now that checklists are being compiled for the Online World Flora, there appear to be approximately 230 known species of *Cordia* and an additional 124 species of *Varronia*, though there are still clearly dozens of undescribed species of both genera awaiting description from undetermined folders in major herbarium collections.

Cordia section *Gerascanthus* has always been a difficult group (see quotes in Wheeler 1942; Johnston 1950). It is morphologically distinct and easily recognizable as a group of species, characterized primarily by its unusual fruits, which are ellipsoidal, single-seeded, fibrous-walled, and most distinctively surrounded and completely enclosed in the persistent calyx and marsescent corolla, with the corolla drying, turning brown and apparently assisting like a small parachute with wind dispersal of the mature fruit. But while the section may be easily recognized, the species have long been difficult to tell apart, prompting Chodat and Vischer (1920) to write "We are, in fact, dealing with species which are but feebly defined morphologically and the taxonomy of which will require revision from time to time as observations in the field increase in number." The species of section *Gerascanthus* are not distributed evenly, and though they occur throughout the Neotropics, most of the South American species were known from few collections or were discovered relatively recently, and the greatest concentration of species is in western Mexico, a group provided with a relatively solid revision (Johnston 1950), though Johnston knew eight of his twelve species from fewer than 3 collections, four from the type only.

MORPHOLOGY

Habit

Most species of *Cordia* sect. *Gerascanthus* are small to medium-sized trees. Only a few species are truly large. *Cordia megalantha* is the largest, occasionally reaching 60 m tall, and *C. alliodora* and *C. trichotoma* often reach 30 m. *Cordia insignis* is a shrub of Brazilian cerrado that apparently grows from an underground xylopodium and flowering individuals are generally only 1–5 m tall and at least in some situations, its above ground stems appear to be annual.

Descriptions of bark are generally not included with most specimen label data, though bark is often a characteristic feature. Most species have smooth pale gray bark. *Cordia morelosana* has dark gray, rough and deeply fissured bark, which is one character that distinguishes it from *C. sonorae*, a species that is morphologically similar and difficult to distinguish from herbarium specimens but has smooth, pale gray bark.

Species of *Cordia* are not infrequently associated with ants but the association is generally casual, with ants living under patches of bark or in hollowed twigs. There are, however, two true myrmecophilous species of *Cordia*, which are unrelated and independently derived (Gottschling, 2005). *Cordia nodosa*, of sect. *Myxa*, has domatia that are swollen, hollow petioles. *Cordia alliodora*, of sect. *Gerascanthus*, has domatia that are hollow, ellipsoid swellings at the ends of branches and the bases of inflorescences that are generally inhabited by small, biting ants of more than a dozen genera (Wheeler 1942). These swellings are filled with a loose pithy material that is presumably easily removed by the ants. The domatia are characteristic of the plants and not simply the result of infestation by the ants as domatia form normally on plants grown in the greenhouse in the absence of the ants. Ants have been associated with all of the trees I have observed in Mexico, but they have frequently been absent from trees in Central America.

Indument

Trichomes of various types are often associated with Boraginales and they are frequently taxonomically useful for distinguishing species and sometimes understanding relationships. While indument is often somewhat variable with a given species, types of individual hairs are often diasgnostic. Indument can vary considerably, not only between species and individuals, but also from one plant part to another, so it is described independently for each successive organ in the descripitions provided here. There are five different types of hairs found in the genus *Cordia* and four of these occur in various species of section *Gerascanthus*; the fifth type, echinate

hairs, are known only in *Cordia cymosa* of section *Myxa*. The four types of hairs found in section *Gerascanthus* include:

1) *Simple hairs*.—These are unicellular hairs that are found in the majority of the species and are variable in size, form, and orientation.
2) *Simple hairs from a distinct pedestal*.—These are thick-walled, unicellular hairs that arise from a swollen, basal pedestal or cystolith. The shaft of these hairs is usually postulate and the hairs are mostly appressed giving rise to strigose, strigillose, and scabrous induments, depending on the length and thicknes of the hairs. The pedestal or cystolith generally appears multicellular. In some cases, the shaft of the hairs weathers and is lost with time, leaving the persistent cystoliths, which result in a rough surface. Hairs from pedestals are common in the genus, but less common in section *Gerascanthus*.
3) *Stellate hairs*.—These are multiply-branched, star-shaped hairs that are characteristic of *Cordia alliodora* and *C. trichotoma* in section *Gerascanthus*. Both of these species have stellate hairs with numerous branches and the hairs are sessile. These differ from the stellate hairs in the related genus *Varronia*, which are stalked and obviously have arisen independently.
4) *Malpighiaceous hairs*.—These are unicellular, T-shaped hairs with two arms and a median attachment. They are rare in *Cordia* but have arisen independently at least four times in the family, each time with a slightly different appearance. They are known only from *Cordia glabrata*, among the species of section *Gerascanthus*, where they give rise to a whitish cast to the undersurface of the leaves.

Leaves

The leaves of species of *Cordia* section *Gerascanthus* are simple, alternate, entire, and are presumed to be deciduous, although this is not confirmed in all species. Many species flower without their leaves, so it is in some cases difficult to pair flowering specimens with sterile specimens with leaves. Leaves vary considerable in size and form and leaf shape and texture are useful characters for distinguishing species. All species have petiolate leaves, and the petioles are generally canaliculate on the adaxial surface, though a few species are only flattened and lack a prominent groove.

Inflorescences

While Boraginales are thought of as characterized by helicoid or scorpioid inflorescences, that condition is apparent only occasionally in *Cordia* and then generally only in the ultimate branches of inflorescences, and it is seldom apparent in species of section *Gerascanthus*. Inflorescences in the section vary from expanded cymes and panicles to compressed and nearly umbellate. All of these are basically cymose-paniculate, but they vary in the degree of elongation of the branches giving rise to a continuum of variation between three different forms:

1) Paniculate inforescences are expanded with a distinct central axis that is a panicle of small cymes, such as in *Cordia macrantha*.
2) Cymose inflorescences are also expanded, but lack a central axis and broader in form, such as is found in *Cordia colimensis* and *C. elaeagnoides*.
3) Umbellate inflorescences are very compressed with none of the branches elongating and giving rise to a nearly umbellate cluster of flowers. In *Cordia globulifera* these are not true umbels but rather a mere contraction of the branches of a branched inflorescence, but in *C. umbellata* they appear to be truly umbellate with all flowers arising from a single point.

While inflorescence type is generally consistent for each species, *Cordia sonorae* has inflorescences that vary from near umbellate in Guerrero, to paniculate on Maria Madre Island, and with both forms in the northern populations in Sinaloa, Sonora, and Chihuahua.

Flowers

Species of *Cordia* sect. *Gerascanthus* are typically distylous and individual plants can readily be separated into long-style and short-style morphs, with respective stamen and style heights varying significantly between the

two. When species are known from adequate numbers of collections, floral measurements are provided separately for the two morphs, though this unfortunately is not the case for the majority of species. In two species, distyly has broken down. In *Cordia alliodora*, the long-style morph has been lost and all individuals have exserted stamens and a short style. In *Cordia trichotoma* an unusual variation occurs, with both long-style and short-style individuals being present in populations but with a third morph with equal stamen and style heights (Gibbs & Taroda 1983).

The species of *Cordia* sect. *Gerascanthus* have a tubular calyx that is usually distinctly 10-ribbed. In a few species, such as *Cordia morelosana*, the indument on the calyx is dense and long enough to obscure the ribs. In other species, such as *Cordia thaisiana*, the calyx is merely striate and lacks the clearly defined ribs characteristic of most species. The calyx persists in all species and encloses the mature fruit.

Section *Gerascanthus* is characterized by corollas that are marcescent and persist, enclosing the mature fruits. As fruits mature, the corollas dry, turn brown, and act as small parachutes that aid in wind dispersal of the fruits. Corollas of species of the section are either tubular with spreading lobes or funnelform. There are generally 5 corolla lobes, though corollas with 4 or 6 lobes are not uncommon in some species. Whether the corolla lobes are oblong, with parallel sides, or ovate to deltate is a feature useful in distinguishing species. The apex of the corolla lobes is generally somewhat rounded or truncate and only in *Cordia megalantha*, *C. latiloba*, and *C. umbellifera* are the corolla lobes drawn to an acute, sharp apex.

The stamens are equal in number to the corolla lobes and all have filaments that are basally adnate to the corolla tube. As the tissue of the filaments is generally distinct to the base of the corolla, measurements given for filament length include the entire length and are followed by the measurements for the free portion above the point of insertion. Filaments can be either glabrous or pubescent at the point of insertion and this is a useful character for distinguishing species and variable only in *Cordia gerascanthus* and *C. morelosana*.

The gynoecium of *Cordia* consists of a superior, bicarpellate ovary that is not divided or lobed. Early in development it is bilocular, but it later becomes falsely 4-locular as a septum forms, dividing each carpel into two separate chambers (Lawrence 1937; Khaleel 1975, 1982). Each of the four locules contains a single, orthotropus ovule but only one develops to maturity, and fruits contain only a single embryo and then seed. All species of the section have an annular, nectariferous disc borne beneath the ovary. These are relatively large compared with the nectaries of species of other sections and are usually visible in dried specimens. *Cordia gracilipes* is characterized by having a disc that is ciliate along the upper margin. The style in *Cordia* is terminal and twice bifid with 4 separate stigma lobes that vary from filiform to clavate or discoid but are always clavate in section *Gerascanthus*.

Fruits

The fruits in species of section *Gerascanthus* are the most distinctive in the genus. They are ellipsoid with a thin, fibrous wall, lacking a mesocarp, and are capped by the persistent base of the style. The fruit swells only slightly during development and remains borne within the persistent calyx and corolla. At maturity, the entire unit is dispersed with the marcescent corolla, aiding in wind dispersal of the fruits.

Pollen

Pollen of the Boraginales is known to be diverse (Avetissian 1956). Nowicke and Ridgway (1973) initially found three types of pollen grains in the genus *Cordia* in a broad sense, including *Varronia* later segregated by Miller and Gottschling (2007). *Varronia* and *Cordia* section *Cordia* each have unique pollen morphology, but *Cordia* section *Gerascanthus* shares pollen grains that are three-colpate to 3-colporate with a spinulose tectum (Nowicke & Miller 1989, 1990) with species of *Cordia* sections *Myxa* and *Superbiflorae*. Largely on this basis, Taroda and Gibbs (1986) grouped these three sections in a broadly defined *Cordia* subgenus *Myxa*.

TAXONOMIC TREATMENT

Cordia section **Gerascanthus** (P. Browne) G. Don, Gen. Hist. 4:380. 1837; A. DC, Prodr. 9:471. 1845; *Gerascanthus* P. Browne, Civ. Nat. Hist. Jamaica 170, t. 29, f. 3. 1756; *Cordia* subgenus *Gerascanthus* Schlect & Cham., Linnaea 5:115. 1830. TYPE: *Cordia gerascanthus* L.

Cordia section **Cerdanae** (Ruiz & Pavon) Roem. & Schultes, Syst. Veg. 4:467. 1819. *Cerdana* Ruiz & Pavon, Fl. Peruv. Prodr. 37, t. 6. 1794; *Cordia cerdana* Roem. & Schultes, Syst. Veg. 4:467. 1819. TYPE: *Cerdana alliodora* Ruiz & Pavon = *Cordia alliodora* (Ruiz & Pavon) Oken.

Small to large trees. Leaves deciduous, alternate, petiolate. Inflorescences paniculate, cymose-paniculate, or sometimes with the axes much reduced and nearly umbellate. Flowers usually distylous, homostylous in *Cordia alliodora*; calyx tubular, usually distinctly 10-ribbed or occasionally merely striate; corolla white, marcescent, tubular with spreading lobes or funnelform, usually 5-merous, the lobes usually spreading; stamens the same number as the corolla lobes, the filaments pubescent or glabrous, the anthers usually oblong; ovary with an evident, usually annular, disc. Fruits borne within the persistent calyx and corolla, wind-dispersed, ellipsoid, the walls thin and fibrous, capped by the discoid base of the style.

Cordia section *Gerascanthus* consists of 23 species, all restricted to the Neotropics. Thirteen species occur in Mexico, and though the species are spread throughout Central America, the West Indies, and South America, there is no other substantial center of diversity.

KEY TO THE SPECIES

Plants with stellate hairs.
- Twigs ending in ant domatia; corollas less than 14 mm long — **C. alliodora**
- Twigs not ending in ant domatia; corollas greater than 15 mm long — **C. trichotoma**

Plants with simple hairs.
- Corolla lobes parallel sided.
  - Staminal filaments glabrous.
    - Inflorescences condensed, nearly umbellate — **C. globulifera**
    - Inflorescences paniculate, decidedly elongate.
      - Calyx striate, glabrous — **C. cardenasiana**
      - Calyx distinctly ribbed, pubescent — **C. gerascanthus**
  - Staminal filaments pubescent.
    - Calyx striate but lacking elevated ribs, glabrous or nearly so.
      - Corollas 15–24 mm long, the lobes 6–10 mm long; inflorescence branches stout — **C. thaisiana**
      - Corollas 22–30 mm long, the lobes 11–14 mm long; inflorescence branches very thin, delicate — **C. goeldiana**
    - Calyx evidently 10-ribbed, puberulent or strigillose to velutinous or pubescent.
      - Lower leaf surface glabrous (Mexico to Costa Rica; West Indies) — **C. gerascanthus**
      - Lower leaf surface whitish, with malpighiaceous hairs (Brazil, Bolivia, Paraguay) — **C. glabrata**
- Corolla lobes widely ovate to deltate, not parallel sided.
  - Corolla lobes acute at the apex.
    - Leaf base acute, rarely obtuse to rounded; calyx striate — **C. megalantha**
    - Leaf base cuneate to obtuse; calyx evidently 10-ribbed — **C. latiloba**
  - Corolla lobes rounded to obtuse at the apex.
    - Staminal filaments pubescent.
      - Inflorescences condensed, nearly umbellate.
        - Calyx nearly glabrous (South America) — **C. umbellifera**
        - Calyx velutinous to villous (Mexico) — **C. sonorae**
      - Inflorescences expanded, cymose to paniculate.
        - Calyx less than 11.5 mm long.
          - Plants flowering with leaves; leaves glabrous, elliptic to narrowly elliptic — **C. tinifolia**
          - Plants flowering while leafless; leaves puberulent on the abaxial surface, elliptic to widely ovate — **C. macvaughii**
        - Calyx greater than 11.5 mm long.
          - Calyx glabrous or nearly so.
            - Leaf blades widely elliptic to elliptic-ovate, 4.5–15.3 cm wide, fruits ellipsoid, the wall fibrous — **C. macrantha**
            - Leaf blades lanceolate to ovate, (2.5–)4–5 cm side, fruits ovoid, the wall hard, bony — **C. iguaguana**
          - Calyx with an evident indument.
            - Shrubs; leaf blades generally greater than 15 cm long, rugose-bullate; inflorescences covered with dense yellow hairs (South America) — **C. insignis**
            - Trees; leaf blades generally less than 15 cm long, not bullate; inflorescences covered with white hairs (Mexico).
              - Erect tree with a distinct central leader; leaves glabrous, elliptic to elliptic-lanceolate — **C. sonorae**
              - Spreading tree without a central leader; leaves scabrous adaxially, elliptic — **C. morelosana**

Staminal filaments glabrous.
- Leaves with whitish malpighiaceous hairs below (South America) — **C. glabrata**
- Leaves glabrous or with simple hairs below (Mexico).

Calyx 6.5–8 mm long ____ **C. igualensis**
Calyx greater than 9 mm long.
  Calyx velutinous, the hairs generally concealing the ribs ____ **C. morelosana**
  Calyx with only minute hairs, the ribs evident.
    Leaves arachnoid-tomentose below ____ **C. guerckeana**
    Leaves glabrous below ____ **C. gracilipes**

1. Cordia alliodora (Ruiz & Pav.) Oken, Allg. Naturgesch. 3(2):1098. 1841. (**Fig. 1**). *Cerdana alliodora* Ruiz & Pav., Fl. Peruv. 2:47. 1799. *Cordia alliodora* (Ruiz & Pav.) Cham. ex A. DC., Prodr. 9:472. 1845. *Lithocardium alliodorum* (Ruiz & Pav.) Kuntze, Revis. Gen. Pl. 2:976. 1891. *Gerascanthus alliodorus* (Ruiz & Pav.) M. Kuhlm & Mattos, Loefgrenia 47:1. 1970. *Gerascanthus alliodorus* (Ruiz & Pav.) Borhidi, Acta Bot. Hung. 34(3–4):396. 1988. TYPE: PERU. HUÁNUCO: Pozuzo, *Ruiz s.n.* (LECTOTYPE: B; photos: F, MO).

Cordia cerdana Roem. & Schult., Syst. Veg. 4:467. 1819.

Cordia alliodora f. *albotomentosa* Chodat & Hassl., Bull. Herb. Boissier 2, 5:304. 1905. TYPE: PARAGUAY: *in campis siccis, prope Concepción*, August, *Hassler 7155* (HOLOTYPE: G).

Cordia alliodora var. *boliviana* Chodat & Vischer, Bull. Soc. Bot. Genève, sér. 2, 12:211. 1921. TYPE: BOLIVIA. BENI: Beni River, *Rusby 1902* (HOLOTYPE: G; ISOTYPES: F, GH, MO, US).

Cordia alliodora var. *glabra* A. DC., Prodr. 9:472. 1845. TYPE: PERU: *Pavón s.n.* (HOLOTYPE: G).

Cordia alliodora var. *tomentosa* A. DC., Prodr. 9:472. 1845. TYPE: PERU: *Pavón s.n.* (HOLOTYPE: G; ISOTYPE: P).

Cordia andina Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:211. 1921. TYPE: BOLIVIA. BENI: Reis, elev. 1,500 ft, *Rusby 1903* (HOLOTYPE: G; ISOTYPES: GH, M, US, WIS).

Cordia chammissoniana var. *complicata* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:215. 1921. TYPE: ECUADOR: 1778, *Ruiz s.n.* (HOLOTYPE: G).

Cordia cujabensis Silva Manso & Lhotsky ex Cham., Linnaea 8:121. 1833. *Lithocardium cujabense* (Silva Manso & Lhotsky ex Cham.) Kuntze, Revis. Gen. Pl. 2:976. 1891. *Gerascanthus cujabensis* (Silva Manso & Lhotzky ex Cham.) Borhidi, Acta Bot. Hung. 34:396. 1988. TYPE: BRAZIL. MATTO GROSSO: Cuyabá, *Manso & Lhotzky 13* (HOLOTYPE: B; ISOTYPE: G).

Cordia gerascanthus f. *martinicensis* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:210. 1921. TYPE: MARTINIQUE: *Hahn 626* (HOLOTYPE: G).

Cordia gerascanthus var. *subcanescens* A. DC., Prodr. 9:472. 1845. TYPE: TRINIDAD: in Ins. Trinnitatis, *Sieber 12* (HOLOTYPE: G; ISOTYPE: M).

Cordia goudotii Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:215. 1921. TYPE: COLOMBIA: Vallee de la Magdelena, *Goudot s.n.* (HOLOTYPE: G).

Cordia rusbyi Chodat, Mem. Torrey Bot. Club 6:83. 1896. TYPE: BOLIVIA: Mt. Tunari, near snow line, 1891, *M. Bang 1110* (HOLOTYPE: NY; ISOTYPES: GH, MO, NY, US).

Cordia velutina Mart., Flora 21 (2, Beibl. 4):85–86. 1838. TYPE: BRAZIL: Morro do Ernesto, prope Cujabá, *Martius 268* (HOLOTYPE: M; ISOTYPES: E, G, NY, P).

Varronia tuberosa Sessé & Moç., PL. Nov. Hisp. 30. 1888. TYPE: MEXICO: In caldissimis Meitepeci montibus, *Sessé & Mociño s.n.* (HOLOTYPE: G).

Tree to 20(–25) m tall, slender, with a narrow crown, bark gray, smooth on young plants, later fissured, twigs ending in obovoid ant domatia to 3(–4) cm long, 1.5–2 cm broad, glabrescent, stellate-pubescent when young. Leaves deciduous; petioles (5–)8–28(–35) mm long, flattened or sometimes canaliculate on the adaxial surface, stellate-pubescent; blades elliptic to narrowly elliptic or slightly obovate, (3.5–)5–17(–20.5) cm long, (1.4–)2–7(–8.5) cm wide, the apex acuminate or acute, the base acute to obtuse, the margin entire or slightly unevenly undulate, the adaxial surface glabrous to sparsely stellate-pubescent, the abaxial surface pale, sparsely to densely stellate-pubescent. Inflorescences terminal, paniculate, often with small leaves subtending the major branches, to 16(–20) cm tall, 25(–30) cm broad, many-flowered, the branches usually densely stellate-pubescent. Flowers on short spurs to 1.5 mm long, bisexual, monomorphic, the stigmas borne below or at the same height as the stamens; calyx tubular, 4–5.5(–6.5) mm long, 2–3(–4) mm wide at the mouth, 10(–12)-ribbed, stellate-pubescent, with 5 small acuminate to attenuate teeth, these 0.5–1(–1.5) mm long; corolla marcescent, white, (8.5–)9.5–12(–14) mm long, with 5 oblong lobes, these 5–7(–8.5) mm long, 2–3(–4) mm wide, the tube (3.5–)4.5–6(–8.5) mm long, stamens 5, the filaments (7–)9–12(–14) mm long, the upper (3.5–)5.5–7.5(–9) mm free, sparsely pubescent at the point of insertion, the anthers oblong, 1.5–2(–2.5) mm long, 0.7–1 mm broad, glabrous; style (4–)4.5–6.5(–8.5) mm long, the stylar branches 1.5–2.5 mm long, the stigma lobes clavate. Fruits enclosed by the persistent corolla and calyx, brown, elipsoid to narrowly elipsoid, 5–7(–8) mm long, 2–2.5 mm broad, one-seeded, endocarp thin, fibrous.

Distribution and habitat.—*Cordia alliodora* is the most wide-ranging species of section *Gerascanthus* ranging from Sinaloa and Tamaulipas in northern Mexico through Central America and the West Indies, to Brazil,

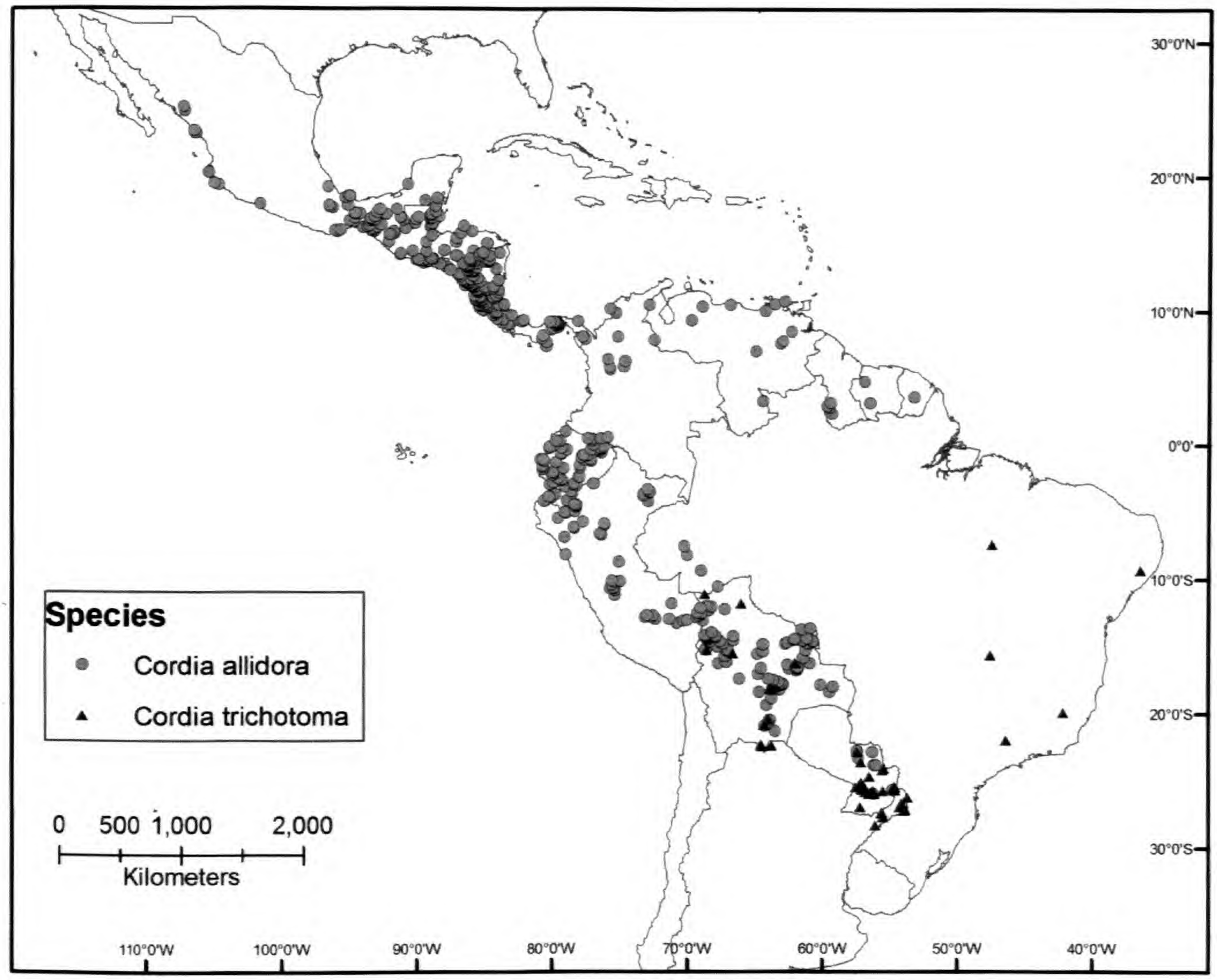


Fig. 1. Distributions of *Cordia alliodora* and *C. trichotoma*.

Bolivia, and Argentina. It is replaced in Eastern Brazil by its closest relative *Cordia trichotoma*. It occurs across a wide vareity of habitats, from dry to wet forests and ranges from sea level to 1,500 m or rarely as high as 1,900 m in elevation.

Representative specimens examined: **ARGENTINA. Jujuy:** Ledesma, *Lillo 57197* (US). **Salta.** Prov. Oran, Ruta No. 34 acceso a Río San Francisco, *Krapovickas et al. 18650* (MO). **BELIZE. Belize:** Gracie Rock, Sibun River, elev. 5–130 m, *Gentle 1561* (MO). **Cayo:** Chiquibul Road, S of Guacamallo Bridge, elev. 30 ft, *Whitfoord 2866* (MO). **Orange Walk:** hillside in high bush, Indian Church, *Arnason & Lambert 17557* (MO). **Stann Creek:** Big Creek, *Schipp 142* (MO). **Toledo:** Maya Mountains, Bladen Nature Reserve, upper Bladen Branch basin, Mukle Bal Tsul ruin, elev. 400 m, *Holst 5407* (BRH, MO, SEL). **BOLIVIA. Beni:** Prov. Vaca Diez, "Potrero municipal," 3 km SW of Riberalta, *Daly et al. 2060* (NY, MO). **Chuqjuisaca.** Naranjitos, camino entre Naranjitos—Río Nuevo, ca. 2 hrs et El Palmar, elev. 1,150–1,800 m, *Lozano 1224* (MO). **Cochabamba:** Cochabamba, *Bang 1178* (MO, NY, US). **La Paz.** S. Yungas, basin of Río Bopi, San Bartolome (near Calisaya), elev. 750–900 m, *Krukoff s.n.* (MO, NY). **Pando.** W bank of Río Madeira, 2 km N of Abuna, *Prance et al. 6114* (MO, NY, US). **Santa Cruz:** Prov. Florida, Loc. de Hierba Buena, elev. 1,300 m, *Steinbach 270* (MO). **Tarija:** 0.2–0.4 km NE of the bridge over Río Pilcomayo of the Villa Montes—Entre Ríos road, 5.5 km (by road) W of center of Villa Montes, elev. 390 m, *Nee 53257* (MO, NY). **BRAZIL. Acre:** near mouth of Río Embira (Tributary of Río Yaco), *Krukoff 4788* (MO, NY, US). **Amazonas:** near mouth of Rio Embira (Tributary of Río Tarauaca), *Krukoff 4788* (MO, NY, US). **Bahia:** Município de Ilheus, Area do CEPEC, Km 22 da Rodovia Ilhéus/Itabuna (BR 415), *Jardim et al. 1102* (NY). **Ceara:** without locality, *Gardner 1780* (F). **Distrito Federal:** Basin do Río Bartolomeu, *Heringer et al. 7183* (NY). **Goias:** Serra do Caiapó, ca. 5 km (straight line) S of Caiapônia, elev. 850 m, *Anderson 9475* (MO). **Maranhao:** Rodovia Belém—Brasília, 5 km de Imperatriz, *Pires 16117* (MO). **Mato Grosso:** Serra do Roncador, Cerrado, ca. 60 km N of Xavantina, elev. 550 m, *Irwin et al. 16668* (NY, US). **Para:** Upper Cupary River, plateau between the Xingu and Tapajos Rivers, *Krukoff 1153* (MO, NY). **Rondonia:** Basin of Río Madera, Km 166–169, Madeira—Mamore railroad near Hutumparana, *Prance et al. 5687* (NY, US). **Sao Paulo:** Município de Matao, 12 km SSE of Matao, *Eiten et al. 3002* (NY). **COLOMB IA. Antioquia:** Cauca Valley, 15 km NE of Bolívar, *Gentry & Renteria 23690* (MO). **Bolivar:** Norosi-Tiquisio trail, Lands of Lova, elev. 1500–600 m,

Curran 177 (US). **Boyaca:** El Humbo, 130 mi. N of Bogotá, elev. 3,500 ft, *Lawrence 581* (MO, US). **Caldas:** Palestina, elev. 1,500 m, *Duque et al. 3753* (US). **Cesar:** 5 km W of Manaure, elev. 440–460 m, *Gentry et al. 60727* (MO). **Cundinamarca:** vicinity of Apulo, elev. 455 m, *Killip et al. 38255* (US). **Huila:** near Algeciras along road to 2 km N of town, Baraya, elev. 1,500 ft, *Little 8093* (US). **Magdalena:** Santa Marta, elev. 150 ft, *Smith 805* (MO, US). **Narino:** De Tumaco, Río Chagüi, Vereda La Honda, elev. 15 m, *Madrigal et al. 787* (MO). **Putumayo:** Margenes del Río Guamues, San Antonio del Guamues, elev. 310 m, *Cuatrecasas 11182* (US). **Risaralda:** Carretera entre caserío Estación Villegas y Hacienda Los Visos, cerca de Río Consota (tributario del Río La Vieja), pie de monte de vertiente occidental de Cordillera Central, acceso desde carretera Cerritos—Pereira en Camino Real, elev. 8 m, *Silverstone-Sopkin & Paz 7229* (MO). **Sucre:** Via Coloso—Chalan—Ovejas, elev. 150–300 m, *Cuadros & Gentry 4660* (MO). **Tolima:** Honda, elev. 250–300 m, *Pennell 3556* (MO, US). **Valle del Cauca:** Mpio. Buena Ventura, Bajo Calima, elev. 40 m, *Devia 471* (MO). **COSTA RICA. Alajuela:** La Palma de San Ramón, *Brenes 5992* (A, F, GH, NY). **Cartago:** streams and cultivated fields with borders of wild vegetation between Jicotea and the Río Pacuare along the road from Turrialba to Moravia, elev. 650–750 m, *Burger & Ramirez 3955* (F, NY, US, WIS). **Guanacaste:** Finca La Pacifica, *Gentry 371* (G, MO, WIS). **Heredia:** Rio Sarapiqui en Puerto Viejo Poia, *Jimenez 3635* (CR, F, NY, US). **Puntarenas:** vicinity of Palmar Norte de Osa, elev. 30 m, *Allen 5879* (B, DC, F, GH). **San Jose:** vicinity of El Generál, elev. 880m, *Skutch 2569* (GH, K, MICH, MO, NY, US). **CUBA. Oriente:** vicinity of El Cuero, *Britton & Cowell 12720* (US). **DOMINICAN REPUBLIC. Azua:** Sierra Martín García, 4 km al W de Galindo, elev. 395 m, *Zanoni et al. 32886* (NY). **Barahona:** Barahona, *Fuertes 209* (US). **Distrito Nacional:** Cuidad de Santo Domingo, Centro Olípico, *Zanoni det al. 27004* (MO, NY). **La Romana:** Cumayasa at 7 km W of La Romana, on highway to San Pedro de Macoris, elev. 5–50 m, *Meijía et al. 8921* (MO). **Pedernales:** Along road between Oviedo and Recta Sansón, *Smith 10041* (MO). **Peravia:** Bani, *Lavastre 2052* (MO). **Salcedo:** Valle del Cibao, 2.8 km SW de Villa Tapia, Próximo a La Barranca, elev. 80 m, *Meijía & Pimentel 23711* (MO). **San Cristobal:** 3.6 km from Pilancón on road to Comatillo, elev. 180 m, *Zanoni & Meijía 16416* (MO, NY). **Santo Domingo:** Santo Domingo, *Rose et al. 4431* (US). **ECUADOR. Bolivar:** Parroquia Telimbela, bosque húmedo Premontano, elev. 2,200 m, *Cerón 14552* (MO). **Canar:** La Troncal, Manta Real, a 20 km al SE de La Troncal, elev. 860 m, *Vargas & Defas 5776* (MO). **El Oro:** between Portorolo (Gold mine near Zaruma) and El Tambo, elev. 600–1,000 m, *Hitchcock 21318* (US). **Esmeraldas:** along river banks near Borbon, Cayapa River, *Jativa & Epling 1053* (MO, US). **Guayas:** junction of the privinces of Guayas, Cañas, Chimborazo, and Bolívar, foothills of the western cordillera near the villaje of Bucay, elev. 1,000–1,250 ft, *Camp E-3739* (MO). **Loja:** Puente chico a 12 km N de Alamor, elev. 760 m, *Samaniego & Vivar 55* (US). **Los Rios:** Río Palenque biological Station, Km 56, road Quevado-Santo Domingo, elev. 150–220 m, *Dodson 6217* (MO). **Manabi:** Parroquia Machalilla, Parque Nacional Machalilla, Comunidad Agua Blanca, Monte Espinoso Troopical, elev. 125 m, *Cerón 11716* (MO). **Morona-Santiago:** Road from Limon (General Plaza) to Macas, 12–16 km N of Limon, elev. 900 m, *Stein 2822* (MO). **Napo:** Río Pucino, first major tributary of Río Aguarico above bridge at Aguarico (near Lago Agrio) elev. 250 m, *Gentry 9728* (MO). **Orellana:** Loreto, Comunidad Waorani de Queihueriuno, elev. 285 m, *Cerón 26415* (QAP). **Pastaza:** Pozo petrolero "Golondrina" de PETRO-CANADA, 25 km al NW del pueblo de Curaray, elev. 400 m, *Rubio & Gudiño 212* (MO). **Pichincha:** Road Chillogallo-Santo Domingo at junction to the new road, elev. 1,050 m, *Holm-Nielson et al. 24863* (MO). **Sucumbios:** Limoncocha, Comunidad Santa Elena, a 8 km de la vía principal a Puerto Itaya, elev. 250 m, *Reyes 261* (MO). **Zamora:** Jamboe Bajo, Eastern border of Podocarpus National Park, elev. 1,100 m, *Clark et al. 3218* (LOJA, MO, QCNE). **EL SALVADOR. Ahuachapan:** vicinity of Ahuachapán, elev. 800–1,000 m, *Standley 19717* (GH, NY, US). **Cabanas:** 2.6 km E of Illobasco, coffee plantation owned by Malcolm Chisholm, elev. 870 m, *Davidse et al. 37087* (MO). **La Libertad:** Finca Santa Maria, W of Santa Tecla, on N slopes of a mountain, elev. 750 m, *Carlson 169* (A, F, UC). **La Paz:** Carretera a Olocuilta, elev. 750 m, *Montalve 3073* (ENCB). **San Miguel:** Finca El Pacayal, Volcán Chinameca, elev. 860 m, *Monro et al. 2943* (MO). **San Salvador:** San Salvador, *Calderon 105* (MO, NY, US). **Santa ana:** San José Ingenio, P.N. Montecristo, elev. 1,200 m, *Martinez 877* (MO). **Sonsonate:** Santa Isabel Ishuatán, elev. 430 m, *Rodríguez et al., 1400* (B, BM, INB, LAGU, MO). **FRENCH GUIANA:** Prés de Saul, *Oldeman 2071* (MO). **GUATEMALA. Alta Verapaz:** vicinity of Caves, SW of Lanquin, elev. 600–1,000 m, *Steyermark 44121* (F, NY, US). **Chiquimula:** Eastern portions of Vera Paz and Chiquimula, *Watson 339* (F, GH, US). **El Progresso:** between Tulumajillo and Finca Montanita in foothills, elev. 330–500 m, *Steyermark 43354* (F, GH, US). **Escuintla:** Finca Las Flores, near Santa Lucia Cotzumalgalpa, *Stead & Styles 92* (FHO, K). **Guatemala:** Trapichite, *Kellerman 6489* (US). **Huehuetenango:** Cafetal of Finca Soledad, 5 mi SE of Barillas, Sierra de los Cuchumatanes, elev. 1,150 m, *Steyermark 49532* (F, US). **Izabal:** Los Amates, *Kellerman 7151* (F, NY, US). **Jutiapa:** Road Guatemala City to Jutiapa at 11 km from Jutiapa, *Stead & Styles 89* (FHI, US). **Peten:** La Libertad and vicinity, *Aguilar 493* (F, GH, MICH, NO, NY). **Quezaltenango:** Columbia, elev. 3,000 ft, *Skutch 2030* (F, G, GH, NY, US). **Retalhuleu:** road Retalhuleu to Las Pilas at ca. 4 km from Retalhuleu, elev. 200 m, *Stead & Styles 216* (FHO, K, MEXU). **San Marcos:** Finca El Porvenir, on Potrero Mataxan along Río Cubus, Volcán Tajumulco, elev. 1,000–1,300 m, *Steyermark 37580* (F). **Santa Rosa:** 6 km from Chiquimulilla on road to Escuintla, elev. 285 m, *Stead & Styles 90* (FHO, NY). **Suchitepequez:** lower slopes of Volcán de Fuego, 7 km SW of Alotenango, elev. 1,100 m, *Williams & Williams 43525* (F, MICH). **Zacapa:** Gualán, elev. 420 ft, *Deam 271* (F, GH, MICH, MO, NY, US). **GUYANA:** western extremity of Canuku Mountains, in drainage of Takutu River, elev. 100 m, *Smith 3096* (US). **HAITI. Nord:** vicinity of St. Michel d'Aralaye, near caverns north of St. Michel, elev. 350 m, *Leonard 7758* (US). **Nord-Ouest:** vicinity of Mole St. Nicholas, *Leonard & Leonard 13209* (US). **HONDURAS. Atlantida:** vicinity of Tela, elev. sea level, *Standley 54523* (F, GH, US). **Colon:** base of Cerro Puerto Arturo on main road, 4 mi E of Trujillo, *Saunders 1046* (F, MO). **Copan:** La Francia, *Whitford & Stadtmiller 22* (CFMR, us). **Cortez:** 3 km from San Pedro Sula, elev. 300 m, *Stead & Styles 70* (FHO, NY). **El Paraiso:** Las Chanpias, elev. 200 m, *Araque 145* (MO). **Gracias a Dios:** S de Comunidad de Krausirpe, Río Patuca, elev. 90 m, *House 2356* (MO). **Intibuca:** near Jesus de Otoro, *Hazlett 1624* (MO). **Islas de la Bahia:** new town of Roatán on the island of Roatán, elev. 50 m, *Harmon & Dwyer 3931* (MO). **Morazan:** San Antonia, elev. 1,500 m, *Molina 748* (F, GH, LL, MEXU, MO, UC, US). **Olancho:** Montaña El Murullo, Catacamas, elev. 1,000 m, *Stead & Styles 56* (FHO, NY). **Santa Barbara:** San Pedro Sula, elev. 1,400 m, *Thieme 422* (F, US). **Teguicigalpa:** between Talanga and Moreceli, *Stead & Styles 61* (FHO, K, NY). **Yoro:** Yoro, elev. 2,800 ft, *Edwards P-752* (MO). **LESSER ANTILLES. Antigua:** Dunning Valley, second growth woodlands on hills in the SW (volcanic) district, *Box 1316* (US). **Barbados:** St. Michel, Black Rock, *Gooding s.n.* **Dominica:** Scott's Head, *Hodge 1627* (GH).

Guadeloupe: Baillif et Neux Habitants, *Stehle 7001* (US). **Martinique:** Tilol a Babets, elev. 300 m, *Stehle 6031* (US). **Montserrat:** Salem, elev. 600 ft, *Proctor 18900* (US). **St: Vincent:** *Smith 1249* (GH, NY). **MEXICO. Campeche:** A 18 km al S de Santa María Xcabak aproximadamente 40 km al N de F. Escárcega, *Cabrera & Cabrera 13471* (MO). **Chiapas:** Mpio of Ocozocautla de Espinosa, 18–20 km N of Ocozocoautla along road to Mal Palo, elev. 800 m, *Breedlove & Thorne 21019* (CHAPA, DS, F, LL, MEXU, MICH, MO NY, RSA). **Colima:** 20–30 mi NE of Colima along roadside, *Thompson & Fields 351* (SLPM, TEX). **Guerrero:** Montes de Oca, Vallecitos, *Hinton et al. 11734* (ARIZ, F, GH, K, MO, NY, US). **Jalisco:** Estación de Biología de Chamela, *Perez 767* (ENCB, MEXU, NY). **Michoacan:** Mpio. de Aguila, 2 km al N de San Juan de Lima, elev. 100 m, *Rzedowski 17976* (ENCB, MEXU). **Oaxaca:** Mpio. of Chiltepec, Chiltepec and vicinity, elev. 20 m, *Calderon 477* (A, LL, UC, US). **Quintana Roo:** a 12 km al Sur del entronque con carretera Escarcega—Chetumal, sobre camino a Ingenio Alvaro Obregón, *Téllez & Cabrera 1688* (MO). **San Luis Potosi:** Mpio. de Xilitla, El Jobo, elev. 200 m, *Rzedowski 10151* (DS, ENCB, MEXU, SLPM, TEX, WIS). **Sinaloa:** Imala, *Gentry 4946* (ARIZ, F, MEXU, MICH, MO, NY, UC). **Tabasco:** 13 km de Villahermosa, *Gonzalex & Perez 4323* (WIS). **Tamaulipas:** Mpio. Gomez Farias, 4–5 km al NW de Gomez Farias, elev. 50 m, *Oliviera & Martinez 3621* (MEXU). **Veracruz:** Alto Lucero, along the road between San Juan Evangelista and Tierra Blanca, just W (approx. 3–5 km) of San Juan Evangelista, elev. 150 m, *Miller & Tenorio 708* (MEXU; MO). **Yucatan:** Lolon, *Flores 4* (F). **NICARAGUA. Atlantico Norte:** E of Finca Waylawás, 2 km from base of Cerro Waylawás, elev. 90 m, *Pipoly 4346* (MO). **Atlantico Sur:** El Zapote, 40 km NE de Nueva Guinea. elev. 130–150 m, *Sandino 4834* (MO). **Boaco:** Camino a Mombachito a los dos lados de la Quebrada Río Grande al NE de Cerro Mombachito, elev. 600–700 m, *Moreno 3236* (MO). **Chinandega:** Road Chinandega to Somotillo at 50 km from Chinandega and 191 km from Managua, *Stead & Styles 41* (FHO, NY). **Chontales:** between Santo Tomás and Villa Somozo, *Bunting & Licht 1110* (F, NY, US). **Esteli:** Ocotal, at ca. 200 km from Managua, elev. 600 m, *Stead & Styles 1* (F, FHO, NY). **Granada:** Environs de Granada, elev. 40 m, *Levy 359* (C, G, GH, P). **Jinotega:** Al NE de Wiwili, camino entre El Carment y Wamblan, a lo largo del Río Coco, elev. 250–400 m, *Araquistain & Moreno 1817* (MO). **Leon:** La Paz, *Baker 2269* (G, GH, K, L, MICH, MO, NY, POM, UC, US). **Madriz:** Faldo W del Cerro Volcán de Somoto (Tepesomoto), elev. 900–1,100 m, *Araquistain & Moreno 2070* (MO). **Managua:** Peninsula de Chiltepe, hacienda Corpus Cristi, 9 km al SE de Mateare, elev. 80 m, *Araquistain & Moreno 1322* (MO). **Matagalpa:** 4 mi downslope from Santa Baría de Ostuma, *Harriman 14622* (ASU, CHAPA). **Nueva Segovia:** 3 km SW of Jalapa, elev. 700 m, *Neill 1684* (HNMN, MO). **Rio San Juan:** near Caño Chontaleno 20 km NE of El Castillo (Río Indio Watershed), elev. 200 m, *Neill 3357* (HNMN, MO). **Rivas:** Isla de Ometepe, al lado N del Volcán Concepción, cafetales do las Angeles y sus alrededores, elev. 250–350 m, *Sandino 536* (MO). **Zelaya:** vicinity of La Luz-Siuna, elev. 150–200 m, *Bunting & Licht 657* (F, UC, WIS). **PANAMA. Bocas del Toro:** vicinity of Chiriquí Lagoon, Old Bank Island, *Wedel 1877* (MO, US). **Canal Area:** Barro Colorado Island, *Croat 7694* (MO). **Chiriqui:** vicinity of San Felix, elev. 0–120 m, *Pittier 5279* (US). **Cocle:** Penonomé and vicinity elev. 50–1,000 ft, *Williams 326* (NY, US). **Colon:** Juan Mina, Río Chagres, elev. 25 m, *Allen 4198* (G, MO). **Darien:** near mouth of Río Paga on Río Tuira, *Gentry 4349* (MO). **Herrera:** vicinity of Ocú, hill above the cantera of Sr. Joaquin Carrizo, limestone area, *Stern et al. 1721* (MICH, MO, US). **Los Santos:** vicinity of Tonosi, Guanico, elev 117 ft, *Stern et al. 1856* (MICH, MO, US). **Panama:** San José Island, *Johnston 570* (GH). **San Blas:** mainland opposite Ailigandi, from mouth of Ailigandi River to 2.5 mi. inland, *Lewis et al. 154* (AAU, MO, US). **Veraguas:** Border of Veraguas, Coclé, and Herrera provinces along the Río Santa María near bridge of Pan American Highway, 16 km SW of Aguadulce, elev. 0–50 m, *Knapp et al. 3348* (MO). **PARAGUAY. Alto Parana:** Estancial Río Bonito, *Zardini & Guerrero 41739* (MO). **Amambay:** West of Colonia Indígena Yvy-Jhu, *Zardini 44918* (MO). **Concepcion:** Arroyo Tagatiyá—Guazú, *Zardini 39776* (MO). **Guaira:** Cordillera de Ybytyruzú, gallery forest 5 km S of Melgarejo, *Zardini & Velásquez 12302* (MO). **Madre de Dios:** Tambopata, Cusco Amazonico, elev. 200 m, *Phillips et al. 455* (MO). **Pasco:** Oxapampa, vicinity of Huancabamba, Hacienda Yanachaga, elev. 1,850 m, *Smith et al. 1682* (MO). **Piura:** Huancabamba, ca. 5 km E of Canchaque on route to Huancabamba, *Dillon & Sánchez 6227* (MO). **Puno:** between Putina and San Ignacio, elev. 1,100 m, *Nuñuz & Muñoz 5154* (MO). **San Pedro:** Yaguareté Forest, *Zardini & Guerrero 44501* (AS, MO). **Tumbes:** Zarumilla, Matapalo, elev. 720 m, *Díaz et al. 5449* (MO). **Ucayali:** Coronel Portillo, Bosque Nacional Alexander von Humboldt, Pucallpa—Tingo María Road, elev. 270 m, *Fröhner 336* (MO). **PERU. Amazonas:** Quebrada Huampami, Río Cenepa, Monte, *Kayap 806* (MO). **Cajamarca:** Monte Seco, elev. 1,800 m, *Soukup 3839* (US). **Cuzco:** 1 km N of Pilcopata, edge of Río Madre de Dios, elev. 510 m, *Gentry 23655* (MO). **Huanuco:** Prov. Leoncio Prado, Rupa Rupa, Castillo Chico, elev. 650 m, *Vasquez 99* (US). **Junin:** La Merced, elev. 2,000 ft, *MacBride 5391* (US). **La Libertad:** Trujillo, "Ajo Sacha," *Meyer et al. 885* (MO). **Lima:** Pista de entrada a la Univ. Nacional Agraria, *Encarnación E34* (MO). **Loreto:** Prov. Maynas, Yanamono, Campamento "Explorama Lodge," zona Bushmaster, elev. 120 m, *Diaz et al. 1146* (MO). **San Martin:** 1 km S of Tarapoto, dry forested slopes overlooking Río Huallaga, elev. 350 m, *Gentry et al. 37716* (MO). **PUERTO RICO. Adjuntas:** Base of Pico Guilarte, 100 m, *Liogier 10015* (NY, US). **Aguada:** On road from Rincón to Aguada, *Vives 2999* (UPR). **Aguadillas:** Aguadillas, *Sargent 573* (US). **Aibonita:** Inter Aibonita et Cari-Blanco, *Sintenis 2946* (US). **Cabo Rojo:** Cabo Rojo in Monte Grande, *Sintenis 709* (MO, US). **Caye:** Caye, *Hess & Stevens 2924* (NY). **Ceiba:** near Ceiba, *Wagner 692* (A). **Fajardo:** near westernmost radio tower just S of the Route3/Route 985 corner, elev. 10 m, *Taylor 9133* (UPRRP). **Isabela:** Bosque Insular de Guajataca, *Little 13516* (A, NY, UPR, US). **Jayua:** Jayua, *Sargent 3050* (US). **Juncos:** Juncos, in Monte Goyo, *sintenis 2038* (US). **Manati:** Km 26, Manatí-Villalba highway, *Little 13712* (US); **Naguabo:** Sierra de Naguabo, Río Icaco and adjacent hills, elev. 465–720 m, *Shafer 3476* (US). **Penuelas:** Penuelas, *Sintenis 4883* (MO, US). **Ponce:** Puente Juana Mata, *Goll et al. 785* (US). **Rio Grande:** Coastal hill 2 mi. N of Mameyes (Palmar), elev. 50 m, *Hartley 13376* (A, US). **Salinas:** Along Route 1 SW of Cayey, 0–2 mi. S of the waterfall and bridge between Routes 162 and 717, *Taylor 6432* (UPRRP). **San Juan:** Río Piedras, on road leading to station's garaje, *Gregory 527* (UPR). **Vega Baja:** Puntas Afuerto, *Goll et al. 1039* (US). **Vieques:** vicinity of Isabel Segundo, *Shafer 2447* (NY, US). **Yauco:** between Susua and Yauco, elev. 300 m, *Alain 9276* (A, NY). **SURINAME. Sipaliwini:** vicinity of Blanche Marie Waterfall on the Nickerie River, elev. 50 m, *Evans 2335* (MO). **TRINIDAD:** Port of Spain, *Fairchild 2863* (US). **VENEZUELA. Amazonas:** Dpto. Atabapo, bosque semicaducifolio en lomeríos adjacenter al Valle medio del Ocamo, elev. 200 m, *Fernández & Yánez 809* (MO). **Anzoateguui:** Puerto La Cruz—El Limon, elev. 600 m, *John 438* (US). **Aragua:** between Villa de Cura and San Juan los Morros, elev. 500 m, *Williams & Alston 94* (US). **Bolivar:** 5 km from Hato de Nuria, E of Miamo, Altiplanicie de Nuria, elev. 400 m, *Steyermark 88411* (US).

Delta Amacuro: Departamento Tucupita, 5–14 km ESE of Los Castillos de Guayana, elev. 50–200 m, *Davidse & González 16342* (MO). **Distrito Federal:** Cerro Naiguatá, ladaras pendientes del lado del marque miran hacia el Norte, arriba del pueblo de Naiguatá, vecinidad de Quebrada Frontina, 5 km al SW de los tanque de la Electricidad de Caracas (Cocuizal), elev. 900–1,100 m, *Steyermark 91829* (US). **Guarico:** 15 km SW of Tamaco along main highway between Altagracia de Orituco and Chaguaramus, elev. 150 m, *Davidse 4218* (MO). **Maracaibo:** Mpio. Jesus Enrique Losssada, La Concepsión, via Cuatro Bocas, *Aristeguieta et al. 6824* (US). **Merida:** 30 km SW of Mérida, along road to El Vigia, near villaje Mesa Bolívar, elev. 1,000 m, *Breteler 3508* (US). **Miranda:** Hills north of Cumbres de Curumo and south of Santa Fe, elev. 900–950 m, *Berry 1762* (MO). **Mongas:** Caicara, *Smith 200-A* (US). **Sucre:** Peninsula de Pari, scrubby bushy-covered slopes bordering the sea, between Guacuco and Guarataro, elev. 80 m, *Steyermark & Liesner 121003* (MO). **Tachira:** Forested level ground or low hills along small streamlet, just south of La Mulata, near Venezuelan-Colombian border, elev. 300 m, *Steyermark et al. 120241* (MO). **Yaracuy:** Secciones de selva nublada a lo largo del camino entre Aroa y Quebrada Honda y Altamira, elev. 1,200 m, *Steyermark & Bunting 105316* (US). **Zulia:** Perija, *Gines 1324* (US). **VIRGIN ISLANDS. St. John:** Cruz Bay, near Raintree Inn, elev. 0–5 m, *Acevedo et al. 2513* (NY). **St. Thomas:** Hills above Charlotte, *Rose 3177* (NY). **Tortola:** Tortola, *Fishlock 121* (MO).

Cordia alliodora is the most widespread species of section *Gerascanthus*, and it is very distinctive in its evident stellate pubescence on its stems, leaves, inflorescence branches, and calyx so it is even readily recognized when sterile. It has the smallest flowers of the section with corollas less than 14 mm long. It is most closely related to and most easily confused with *Cordia trichotoma*, but differs in having smaller flowers, (8.5–)9.5–12(–14) mm corolla versus 12–17 mm. *Cordia alliodora* also consistently has ant domatia, which *C. trichotoma* does not form. *Cordia trichotoma* also differs in generally having leaves that are tomentose on the lower surface, while *C. alliodora* is generally only pubescent, though some specimens from Cuba and Hispaniola approach tomentose. Gibbs and Taroda (1983) also showed that *C. alliodora* is homostylous, while *C. trichotoma* has three morphs, a long-style form, a short-style form, and a third morph where stamens and styles are the same height.

Cordia alliodora is the most important native timber tree cultivated in Central America (Johnson & Morales 1972) and its wood is valued for a variety of uses.

2. Cordia cardenasiana J.S. Mill., Ann. Missouri Bot. Gard. 74(3):672–673, f. 2. 1987. (**Fig. 2**). TYPE: GUATEMALA. PETÉN: Cardenas, on rocky hill, 1967, *Contreras 6835* (HOLOTYPE: LL; ISOTYPES: DS, F, LL, US).

Tree to 15 m tall, the twigs glabrous. Leaves deciduous; petioles 8–30 mm long, canaliculate on the adaxial surface, glabrous; blades elliptic, 4.4–11.4 cm long, 2.4–4.5 cm wide, the apex acute to acuminate, the base acute, the margin entire, the adaxial surface glabrous but evenly papillose, the abaxial surface glabrous. Inflorescences terminal, cymose-paniculate, to 15 cm long, 11 cm broad, the branches very short puberulent. Flowers distylous, on short spurs to 1.5 mm long; calyx tubular 5–6 mm long 3–3.8 mm wide at the mouth, unevenly lobed and tearing upon dehiscence or dehiscing circumscissily, striate or faintly costate, faintly short puberulent; corolla white, tubular with somewhat spreading lobes, 14.2–16.8 mm long, 5 merous, the lobes oblong, 5.2–6.2 mm long, 4.8–5.9 mm wide, the tube 4.7–5.1 mm long; stamens 5, the filaments 9.8–11.5 mm long, the upper 7–7.6 mm free, glabrous, the anthers oblong, 2.3–3 mm long; ovary obloid, 1.2–1.4 mm long, 1.3–2.5 mm broad; disc anular, 1.4 mm tall, 1.3 mm broad, glabrous; style 6.8–7 mm long, the stylar branches 1.4–1.6 mm long, the stigma lobes clavate. Fruits unknown.

Distribution and habitat.—This species is known only from the type locality in Petén, Guatemala, where it occurs in seasonally dry forests.

Cordia cardenasiana is a small tree that is presumably quite attractive in flower. It is probably most closely related to, and most easily confused with, *C. gerascanthus* with which it shares glabrous leaves, a terminal, cymose-paniculate inflorescence, and parallel-sided corolla lobes, but it differs in having a calyx that is shorter (less than 18 mm long) and the surface of its calyx is only striate or faintly costate, not distinctly ribbed.

3. Cordia colimensis I.M. Johnst., J. Arnold Arbor. 31:186. 1950. (**Fig. 3**). *Gerascanthus colimensis* (I.M. Johnst.) Borhidi, Acta Bot. Hung. 34:396. 1988. TYPE: MEXICO: COLIMA: Manzanillo, 1890, *E. Palmer 989* (HOLOTYPE: GH; ISOTYPES: G, K. LE, MO, NY, UC, US).

Tree to 10 m tall, the twigs glabrous with vertical, elliptic lenticels. Leaves deciduous; petioles 6–18 mm long, canaliculate on the adaxial surface, glabrous; blades lanceolate to narrowly elliptic (3.7–)5–10.5 cm long, 1.5–3(–3.7) mm wide, the apex attenuate to acuminate, sometimes acute, the base acute, the margin entire, the adaxial surface glabrous, the abaxial surface glabrous. Inflorescences terminal, compressed cymose-panicu-

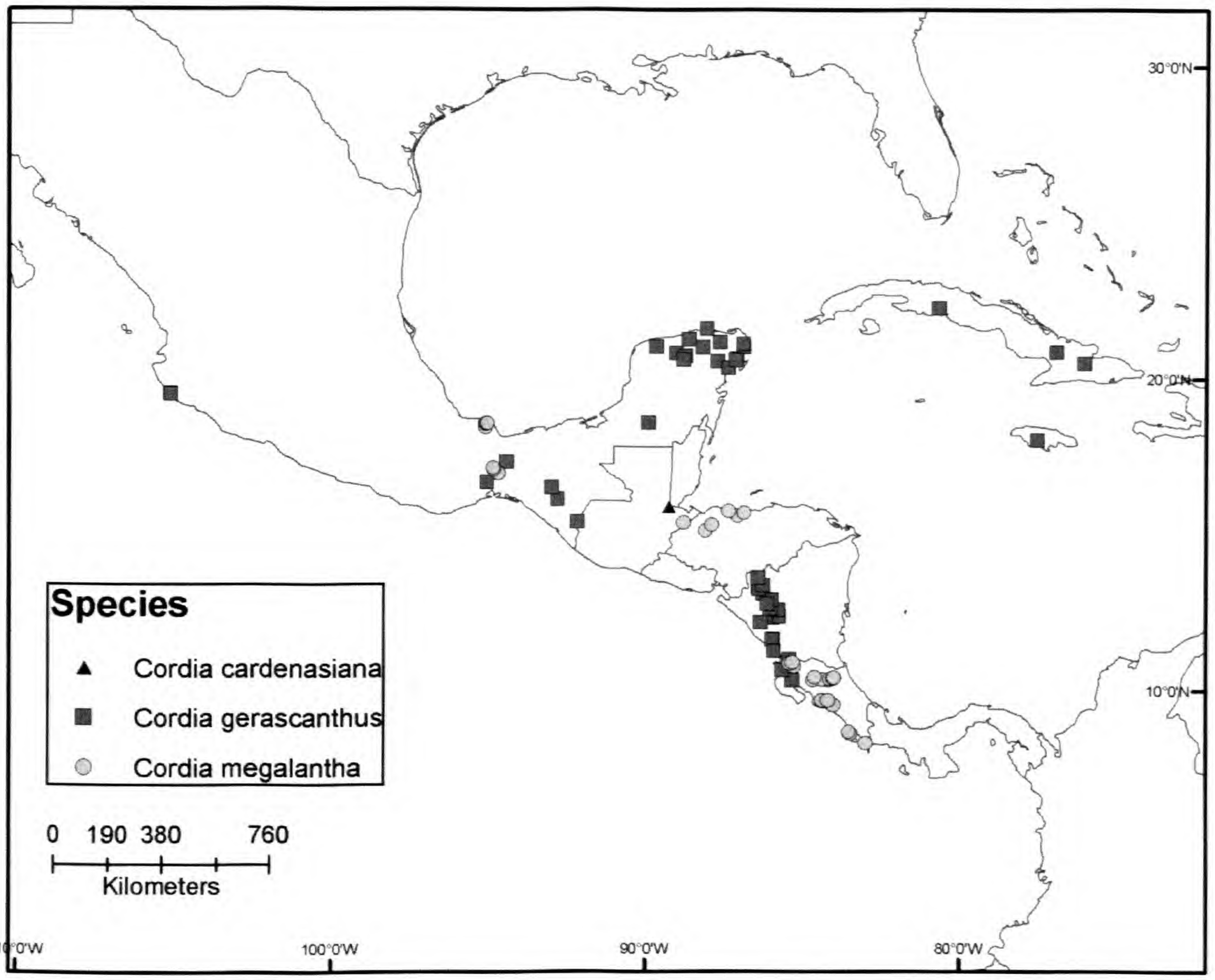


FIG. 2. Distributions of *Cordia cardenasiana*, *C. gerascanthus*, and *C. megalantha*.

late, to 6 cm long, 8.5 cm broad, 11–30 or more flowered, the branches of the inflorescence tomentose, the hairs wavy, short, dark brown. Flowers distylous, nearly sessile at the tips of inflorescence branches; calyx tubular, 12–15 mm long, 3–3.5 mm wide at the mouth, usually 5-lobed, sometimes with fewer lobes, the lobes unevenly shallowly triangular to deltate, 10-ribbed, each rib with a central furrow making the calyx appear falsely 20-ribbed, glabrous; corolla marcescent, white, funnelform, 2.8–3 cm long, 5-lobed the lobes very widely ovate to transversely widely oblong, 7–10 mm long, 9–11 mm wide, the tube 10–16 mm long, glabrous; stamens 5, the filaments 21–24 mm long, the upper 10–15 mm free, pubescent at the point of insertion, the anthers oblong, 2.5–3 mm long; ovary broadly obovoid, 1–2.5 mm long, 1–1.3 mm broad, glabrous; style 14–23 mm long, the stylar branches ca. 4 mm long, the stigma lobes clavate. Fruits unknown.

Distribution and habitat.—This species is known from only three collections from western Mexico where it occurs in coastal parts of Colima and Jalisco from sea level to 550 m in dry forests.

Specimens examined: **MEXICO. Jalisco:** ills between Bahía Navidad and La Manzanilla on Bahia Tenacatita, E facing summits 3 mi. W of the Autlan-Navidad highway, elev. 550 m, *McVaugh 21017* (MICH); 1 km al N de La Manzanilla, sobre el camino a Tenacatita, *Rzedowski 14846* (ENCB, MEXU, MICH, TEX).

4. Cordia elaeagnoides A. DC., Prodr. 9:474. 1845. (**Fig. 3**). *Lithocardium elaeagnodes* (A. DC.) Kuntze, Revis. Gen. Pl. 2:977. 1891. TYPE: MEXICO. OAXACA: Chjuitan inter Tehuantepec et Roca del Monte, *Andrieux 197* (HOLOTYPE: G; ISOTYPE: K).

Cordia exsucca Sessé & Moçiño, Fl. Mexic., ed. 2, 45–46. 1894. TYPE: MEXICO: habitat in Apatzingani aliisque calidissimis Novae Hispaniae locis. Floret Octobri, *Sessé & Moçiño s.n.* (LECTOTYPE: MA).

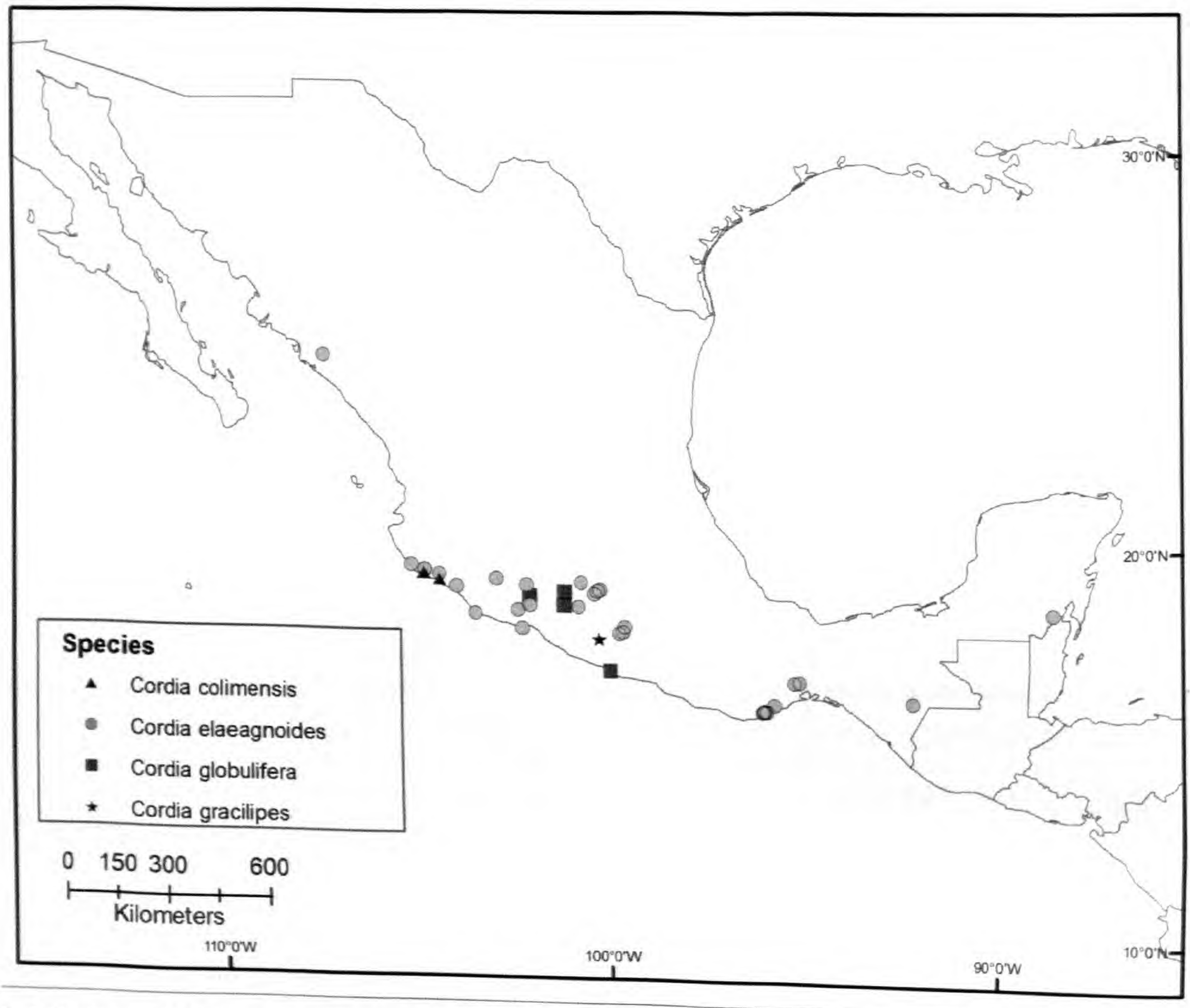


Fig. 3. Distributions of *Cordia colimensis*, *C. elaeagnoides*, *C. globulifera*, and *C. gracilipes*.

Tree to 15(–20) m tall, the bark furrowed, light brown, young twigs canescent, the hairs straight, 0.1 mm long or less, appresssed. Leaves deciduous; petioles (12–)17–65(–85) mm long, flattened to canaliculate on the adaxial surface, canescent, the hairs straight, short, appressed; blades ovate, (4.5–)5.5–15.5(–21) cm long, (2.1–)3.5–10(–12.5) cm wide, the apex usually acuminate but sometimes acute or attenuate, the base usually obtuse and abruptly decurrent along the petiole but varying from acute to truncate, the margin entire, the adaxial surface glabrescent to rarely hirtellous, the hairs from a flat pedestal, stiff, short, appressed, the abaxial surface densely to sparsely canescent, the hairs straight, short, appressed. Inflorescences subtended by small leaves, near the end of branches, broad-flattened cymose-paniculate, compound, composed of separately arising branches variously terminal, lateral, and axillary, (12–)17–24(–30) cm broad, with 45-several hundred flowers, the branches canescent, the hairs straight, short appressed. Flowers distylous, on pedicels 1–3(–4) mm long, the buds apiculate; calyx urceolate to campanulate, (5.5–)6–8(–10) mm long, 4–5(–6) mm wide at the mouth, unevenly (10–)15(–18) ribbed, unevenly 5-lobed, the lobes apiculate, the surface canescent, the hairs 0.2–0.3 mm long, appressed; corolla marsescent, white to cream, funnelform, 15–22 mm long, 5-lobed, the lobes oblong-ovate, (6–)8–11(–12) mm long, 5–6(–8) mm wide, the tube 5–8 mm long; stamens the same number as the corolla lobes, the filaments (6.5–)8–11(–12) mm long, the upper 1.5–3(–4) mm free, glabrous, the anthers oblong, 1.5–2 mm long; ovary ovoid to conical, 2–4 mm long, glabrous or rarely with scattered hairs, the stylar branches 1.8–3(–3.6) mm long, the stigma lobes clavate to discoid. Fruits enclosed by the persistent calyx and corolla, dark brown, dry, the stone ovoid, 5 mm long, 3 mm broad, endocarp bony.

Distribution and habitat.—*Cordia elaeagnoides* is a reasonably common species in dry forests of western

Mexico ranging from Chiapas in the south to Sinaloa in the north and it can be found from sea level to 1,200 m in elevation.

Representative specimens examined: **MEXICO. Chiapas:** San Geronimo, *Collins & Boyle 23* (US). **Colima:** 15 km SSW of Colima on route 110 toward Manzanillo, *Miller et al. 273* (MEXU, MO). **Guerrero:** along the road between Filo de Caballo and Milpillas, just W of Xochipala, ca. Km 13, elev. 1,000 m, *Miller et al. 491* (MEXU, MO). **Jalisco:** along Mexican Highway 80 between La Huerta and barra de Navidad, between La Huerta and Km 231, elev. 500 m, *Miller et all 388* (MEXU, MO). **Mexico.** Calera, dist. Temascaltepec, elev. 790 m, *Hinton 5378* (G, GH, K, NY). **Michoacan:** along the road between Cuidad Altamirano and Huetamo de Nunez, just N of El Pinazn Colorado, S. of San Lucas, elev. 370 m, *Miller & Tenorio 657* (MEXU, MO). **Oaxaca:** Km 12 de la carreteraTehuantepec al S de Salina Cruz, elev. 25 m, *Cedillo Trigos & Lorence 456* (MO). **Quintana Roo:** en el Palmar, a 7 km al sur de Ucum, sobre la carretera a La Unión, cerca del Rip Hondo, *Cabrera et al. 2636* (MO). **Sinaloa:** central plaza of Mocorito, *Breedlove 16724* (CAS).

Cordia elaeagnoides is a common tree on the Pacific slope of western Mexico and is dominant in some of the places where it occurs. Originally considered sectionally distinct and placed in section *Rhabdocalyx* by DeCandolle (1845) because of its hard, bony-walled fruits, recent molecular studies show that it is definitely related to the other species of section *Gerascanthus* (Gottschling et al. 2005). It is distinct in its cymose inflorescences and hard, bony-walled fruits. Although this species seldom excedes 15 m in height, it is highly valued for its wood in regions where it occurs. In western Mexico, it is one of the most commonly used species for the construction of furniture. Common names include "Grisiño" (Chiapas), "bocote," "gueramo" (Michoacán, Guerrero), "ocotillo meco" (Oaxaca) and "barsino" (Guerrero, Michoacán) (Standley 1924).

5. Cordia gerascanthus L., Systema Naturae, Editio Decima 2:936. 1759. (**Fig. 2**). *Lithocardium gerascanthus* (L.) Kuntze, Revis. Gen. Pl. 2:977. 1891. *Cerdana gerascanthus* (L.) Moldenke, Phytologia 1:16. 1933. TYPE: JAMAICA: *Patrick Browne s.n.* (LINN 253.5). Apparently unaware that there was a specimen in the Linnaean herbarium, Riedl designated, Browne, Civ. Nat. Hist. Jamaica, 170, t. 19, f. 3 (1756), superfluously as a lectotype in Kalkman et al. (ed.), Fl. Malesiana, ser.1, 13:77. 1997.

Cordia bracteata A. DC., Prodr. 9:472. 1845. *Lithocardium bracteatum* (A. DC.) Kuntze, Revis. Gen. Pl. 2:976. 1891. TYPE: CUBA: 1828, *Sagra s.n.* (HOLOTYPE: G).

Cordia geraschanthoides Kunth, Nov. Gen. Sp. 3:69. 1818. *Lithocardium gerascanthodes* (Kunth) Kuntze, Revis. Gen. Pl. 2:977. 1891. *Gerascanthus gerascanthoides* (Kunth) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: CUBA: near Havana and port La Trinidad, *Bonpland 1331* (HOLOTYPE: B).

Cordia langlassei Loes., Repert. Spec. Nov. Regni Veg. 12(322–324):240. 1913. TYPE: MEXICO. GUERRERRO: Rives du Rio Coyuquilla, elev. 150 m, Feb 1899, *Langlasse 834* (HOLOTYPE: B; ISOTYPES: G, GH, K, US).

Cordia rothschuhii Loes., Bot. Jahrb. Syst. 60(4):368. 1926. TYPE: NICARAGUA. MATAGALPA: ca. 1.8 km SW of ford of Río Grande de Matagalpa on road to Terrabona, elev. 410 m, 12° 38" N, 86° 01" W, 26 Dec 1978, *W.D. Stevens 11279* (NEOTYPE, here designated: MO). I confirmed that there is no specimen of Rothschuh at B and I borrowed the Central American material from BR, F, GH, L, and US where there were apparently some of his duplicates and there are no specimens there. I therefore conclude that the type at B (*Rothschuh 462*) was destroyed.

Tree to 15(–30) m tall, to 30 cm dbh, the bark light gray, smooth, the twigs glabrous. Leaves deciduous; petioles (8–)12–30(–40) cm long, canaliculate on the adaxial surface, glabrous; blades elliptic oblong to lance-ovate, (4.5–)6–15(–20) cm long, (2–)2.6–6(–8.5) cm wide, the apex acuminate or acute, the base acute to nearly obtuse, the margin entire, the adaxial surface glabrous, the abaxial surface glabrous. Inflorescences terminal, paniculate or condensed, often consisting of clusters of panicles, 2.5–12.5 cm long, 2.5–9 cm broad, the branches densely pubescent to tomentose, the hairs usually dark. Flowers distylous, sessile or on short spurs to 2 mm long; calyx tubular, 8–9(–9.8) mm long, 2.5–3.5 mm wide at the mouth, 10-ribbed, puberulent or strigillose to velutinous or pubescent, usually 4–5 lobed, the lobes uneven, deltate-acuminate, (0.7–)1.1–1.7 mm long; corolla white, tubular with spreading lobes, 20–27 mm long, 5-lobed, the lobes oblong, 8–10(–13) mm long, (5–)6–8 mm wide, the tube 6.2–8.5 mm long; stamens 5, the filaments in long-styled flowers 10.5–14 mm long, the upper 4.3–6.2 mm free, in short-styled flowers (12–)15–17(–21) mm long, the upper 6.7–11 mm free, puberulent to sparsely pubescent at the point of insertion, rarely glabrous, the anthers oblong, (2–)4–5 mm long; ovary depressed ovoid to ovoid, 0.7–1.3(–1.8) mm long, 1–1.6(–2) mm broad, glabrous; style in long-styled flowers 10–17 mm long, in short-styled flowers 8.5–11(–12) mm long, the stylar branches 2–3 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid to narrlowly ellipsoid, 7–8 mm long, 3.5–4 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—*Cordia gerascanthus* is one of the more wide-ranging species occuring from Jalisco and Tamaulipas, in northern Mexico, south through Central America as far as Guanacaste in Costa Rica and east into the Greater Antilles. It occurs in dry forests throughout its range from sea level to 1,000 m.

Representative specimens examined: **BELIZE:** Hill Bank, *Record BH31* (CFMR, US). **CAYMAN ISLANDS:** Grand Cayman, Spot Bay, *Millspaugh 1300* (NY). **COSTA RICA. Guanacaste:** entre Cañas y Tilarán, *Fournier 1405* (SJ). **CUBA. Camaguey:** vicinity of La Gloria, *Shafer 558* (US). **Isla de Pinos:** near Nueva Gorgona, *Curtiss 370* (MO, US). **La Habana:** Santiago de Las Vegas, *van Hermann 708* (F, US). **Las Villas:** Soledad, Cienfuegos, *Jack 4721* (US). **Oriente:** Cabañas Bay, *Britton & Cowell 12806* (NY, US). **Pinar del Rio:** Los Palacio to San Juan de Zayas, *Shafer 11820* (MO, US). **Santa Clara:** Río San Juan, *Britton et al. 5902* (NY). **EL SALVADOR. La Libertad:** La Libertad, *Allen 7204* (F, LL, MICH, NY, UC, US). **San Vicente:** Tecoluca, elev 200 ft, *Shannon 5044* (US). **GUATEMALA:** Los Andes District, *Record G11* (CFMR, US). **HAITI. Grand-Anse:** Massif de la Hotte, western group, Dame Marie, near Faux-Cap, *Ekman 10504* (US). **HONDURAS. Atlantida:** Lancetilla Valley, near Tela, elev. 20–600 m, *Standley 53119* (F, US). **Comayagua:** Valley of Camayagua river, just off road Siguatepeque to Tegucigalpa, *Stead & Styles 720* (US). **JAMAICA. Hanover:** Dias, elev. 500–650 ft, *Proctor 20672* (NY). **Manchester:** Gut River, *Proctor 35506* (MO). **Portland:** Happy Grove, near Hectores River, elev. 200 ft, *Proctor 6497* (US). **St: Andrews:** Berwick, *Hart s.n.* (US). **St: Ann:** Union Hill, 2.5 mi. SSW of Moneague, elev. 1,900 ft, *Proctor 6497* (US). **St: Elizabeth:** Pepper, elev. 250 m, *Miller 1370* (US). **St. Thomas:** Cambridge Hill, elev. 900 ft, *Proctor 8503* (US). **MEXICO. Campeche:** Mun. Calakmul, a 8 km al NE de Conhuás, camino a Nadzcaan, elev. 170 m, *Martínez 34965* (MEXU, NY). **Chiapas:** Mpio. Chiapa de Corzo, Chorreadero de Tuxtla, 5.6 mi. E of Chiapa de Corzo along Mexican Highway 190, elev. 2,500 ft, *Breedlove 9122* (F, MICH, US). **Guerrero:** road from Acapulco to Pié de la Cuesta, *Carlson 3053* (F, NY). **Jalisco:** near the U.N.A.M. biological station at Chamela, along the turnoff from Mexican Highway 200 to Chamela, just beyond causeway, elev. near sea level, *Miller et al. 403* (MEXU, MO). **Oaxaca:** Km 13, La Venta al S de La Ventosa, *Cedillo Trigos 549* (MO). **Quintana Roo:** Coba, en el camino las Pinturas, elev. 20 m, *Lopez et al. 1060* (MEXU). **Tamaulipas:** E slope of limestone Sierra del Abra 10 mi. W of main highway on Ocampo road, elev. 900 ft, *Johnston & Crutchfield 5202* (MEXU, MICH, TEX). **Veracruz:** Mpio. de Paso de Ovejas, Mata Mateo, elev. 100 m, *Ventura 7684* (ENCB). **Yucatan:** Calotmul, *Gaumer 2161* (B, C, F, MO, US). **NICARAGUA. Boaco:** Santa Rita, SE of Empalme Boaco, elev. 220 m, *Stevens 22849* (MO). **Esteli:** Km 179 on Highway 1, ca. 5.5 km S of bridge at Condega, elev. 560 m, *Stevens 5761* (HNMN, MO). **Granada:** Granada, *Orsted 12837* (C, US). **Managua:** Sierra de Managua, elev. 600–900 m, *Garnier A572* (US). **Matagalpa:** ca. 1.8 km SW of Ford on Río Grande de Matagalpa on road to Terrabona, elev. 410 m, *Stevens 11279* (HNMN, MO). **Nueva Segovia:** 2.8 km S of Mozonte—San Fernando road (at Km 239) along road to San Antonio, elev. 650 m, *Stevens & Montiel 30519* (MO). **Rivas:** San Juan del Sur, camino entre Las Playas de Marsella y Rivas, elev. 0–100 m, *Rueda et al. 1422* (MO).

Cordia gerascanthus is one of the more widespread members of the section found throughout Mexico, Central America, and the West Indies. It can be recognized by its combination of parallel-sided corolla lobes, evidently ribbed calyx, and paniculate inflorescence. It is unusual in exhibiting geographic variation in several characters that are generally fixed within other species. Populations in the Yucatán peninsula have glabrous staminal filaments, but they are pubescent at the point of insertion throughout the rest of its range. Populations in the Greater Antilles generally flower while the plants have leaves as opposed to the mainland populations that generally flower when leafless. The species is characterized by having parallel-sided corolla lobes and these are generally truncate at the apex, but rounded in some individuals from the west coast of Mexico. Hummingbirds have been observed as common pollinators in western Mexico (pers. obs.).

6. Cordia glabrata (Mart.) A. DC., Prodr. 9:473. 1845. (**Fig. 4**). *Gerascanthus glabratus* Mart., Flora 21(2, Beibl. 4):87–88. 1838. *Lithocardium glabratum* (Mart.) Kuntze, Revis. Gen. 2:977. 1891. TYPE: BRAZIL. MINAS GERAIS: high dry campo near Contendas, *Martius, Herb. Bras. 1569* (HOLOTYPE: M; ISOTYPES: B; F, MO, photos of M sheet).

Cordia longipeda Mez, Bot. Jahrb. 12:550. 1890. *Lithocardium longipedum* Kuntze, Rev. Gen. 2:977. 1891. *Cordia glabrata* var. *longipeda* Chodat, Bull. Soc. Bot. Genève, ser. 2, 12:212. 1921. TYPE: BRAZIL. MATTO GROSSO: Cuyabá, *Martius Herb. Bras. 1068* (ISOTYPES: B, G-DC, K, NY).

Cordia glabrata var. *amambayensis* Chodat, Bull. Soc. Bot. Genève, ser. 2, 12:212. 1921. TYPE: PARAGUAY: Sierra de Amambay, Sep, *Rojas in Hassler 10600* (HOLOTYPE: G-BOISS; ISOTYPES: B, BM, G-DEL).

Lithocardium longipedum var. *eriophyllum* Kuntze, Rev. Gen. 2:206. 1891. *Cordia glabrata* f. *eriophylla* (Kuntz) I.M. Johnst., Contr. Gray Herb. 92:13. 1930. TYPE: PARAGUAY: Concepción, Sep 1892, *Kuntze s.n.* (NY).

Cordia glabrata var. *orbicularis* Chodat & Vischer in Chodat, Bull. Soc. Bot. Genève, ser. 2, 12:212. 1921. TYPE: PARAGUAY: au pourtour du lac Ypacaray, *Hassler 3222* (LECTOTYPE, here designated: G-00094802).

Cordia longipeda Mez, Rev. Gen. 2:977. 1891. *Lithocardium longipedium* (Mez) Kuntze, Revis. Gen. Pl. 2:977. 1891. *Gerascanthus longipedus* (Mez) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: BRAZIL. MATTO GROSSO: Cuyabá, 30 Jun 1902, *Malme 1869* (ISOTYPES: B, G, K, NY).

Cordia longituba Chodat & Vischer in Chodat, Bull. Soc. Bot. Genève, Ser. 2, 12:213. 1921. TYPE: PARAGUAY: Rincon, between Concepción and Horqueta, 1914, *Chodat 363* (HOLOTYPE: G).

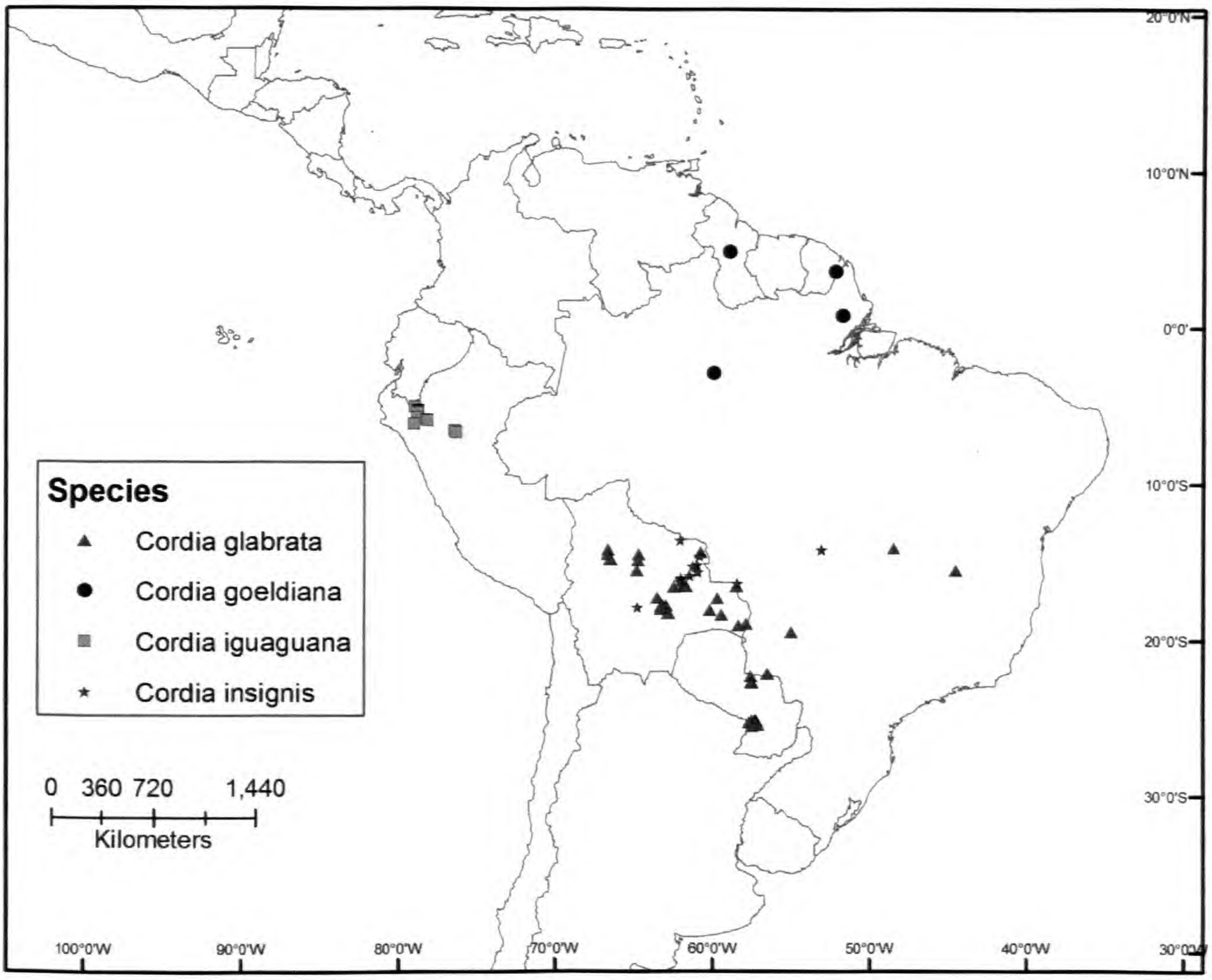


Fig. 4. Distributions of *Cordia glabrata*, *C. goeldiana*, *C. iguaguana*, and *C. insignis*.

Tree to 5(–6) m tall, the twigs sericeous when young, often hollow and inhabited by ants, the hairs malpighiaceous, later glabrous and waxy. Leaves deciduous; petioles (6–)11–27(–37) mm long, canaliculate to flattened on the adaxial surface, glabrous to sericeous; blades ovate to widely ovate, (3.5–)6–14(–20.5) cm long, (3–)4–9(–14) cm wide, the apex obtuse to acute or rounded and occasionally abruptly acuminate, the base rounded to obtuse, occasionally approaching subcordate, the margin entire, the adaxial surface glabrous and lustrous, sometimes with scattered patches of malpighiaceous hairs, the abaxial surface sericeous with malpighiaceous hairs or these sometimes fused and reduced with the abaxial surface appearing essentially glabrous. Inflorescences paniculate, (2–)6–10(–18) cm long, (2–)5–12 cm broad, the branches sericeous to densely puberluent. Flowers distylous, on short pedicels 1–2 mm long; calyx tubular, 8–10(–14) mm long, 3–4 mm wide at the mouth, prominently 10-ribbed, densely white puberulent, 3–5 lobed, the lobes uneven, ovate to deltate, 1–2 mm long; corolla white 21–28(–34) mm long, 5-lobed, the lobes oblong, parallel-sided or nearly so, or nearly rounded, 8–13 mm long, 7–10 mm wide, rounded at the apex, the tube 8–12 mm long; stamens the same number as the corolla lobes, the filaments 15–22 mm long, the upper 5–10 mm free, glabrous, the anthers oblong, 2–4 mm long; ovary ellipsoid, 2–3 mm long, the style 17–20 mm long, the stylar branches 2–4 mm long, the stigmas filiform. Fruits enclosed by the persistent calyx and corolla, brown, ovoid, 8–10 mm long, 5–6 mm wide, one-seeded, the wall fibrous.

Distribution and habitat.—Cordia glabrata occurs in SW Brazil and adjacent Bolivia and Paraguay, where it is found in dry forest and cerrado vegetation from sea level to 500 m.

Representative specimens examined: **BOLIVIA. Beni:** Prov. Ballivian, Espiritu en las zona de influecia del Río Yacuma, elev. 200 m, *Beck* 2588 (MO). **Santa Cruz:** Nuflo de Chavez, 1 km E of San Ramón, elev. 225 m, *Nee 41582* (MO, NY). **BRAZIL. Bahia:** Santa Maria da Vitória, ca. de 5 km na Rod. Santa Maria da Virória/Bom Jesus da Lapa, *Jardim 924* (MO). **Goias:** entre Brasilia e Niquelandia, *Pires et al. 9683* (F, US). **Matto Grosso:** Corumbá, próximo a Bolivia, *Ellias de Paula 1448* (US). **Minas Gerais:** Entre Pirapora de Monte Claros, *Castellanos 24239* (F). **Para:** Fazenda Prof. Getulino, near Redencao, *Ratter et al. 6871* (NY). **PARAGUAY. Alto Paraguay:** Puerto Casado, *Degen 3352* (CTES, FCQ, MO). **Amambay:** Parque Nacional Cerro Cora, cerca del Cerro Muralla, *Soria 7163* (FCQ, MO). **Boqueron:** Col. Fernheim, Filadelfia, *Vanni et al. 2122* (CTES, MO). **Central:** Ascunción, calle Artigas y Vía Ferrea, *Schinini 5092* (MO). **Chaco:** Parque Nacional Defensores del Chaco, Cerro León, baldzone on top of Cerro León, *Hahn 1559* (MO). **Concepcion:** Estancia Centurión, Potrero Central, elev. 200 m, *Stevens et al.* 26251 (FCQ, MO). **Cordillera:** Camino entre Emboscada, Arroyos Y Esteros, Río Piribebuy, *Zardini 6793* (MO, PY). **Paraguari:** Pie de Cordillera, Campo orillas de montes, *Rojas 1327* (AS, MO).

Cordia glabrata is a common species in central Brazilan cerrado vegetation and it can be easily recognized by its leaves that are pale white on the lower surface. It is the only species of the section with malpighiaceous hairs.

7. Cordia globulifera I.M. Johnst., J. Arnold Arbor. 31:184. 1950. (**Fig. 3**). *Gerascanthus globulifera* (I.M. Johnst.) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: MEXICO. GUERRERO: Acapulco and vicinity, Oct 1894 to Mar 1895, *Palmer 573* (HOLOTYPE: GH; ISOTYPES: F, K, MICH, MO, NY, UC, US).

Cordia nelsonii I.M. Johnst., J. Arnold Arbor. 31:183. 1950. *Gerascanthus nelsonii* (I.M. Johnst.) Borhidi, Acta Bot. Hung. 34:398. 1988. TYPE: MEXICO: *E.W. Nelson 6924* (HOLOTYPE: GH; ISOTYPE: US).

Small tree to 6(–10) m tall, the bark smooth, light gray, the twigs sparsely strigillose, later glabrous and sparsely lenticillate. Leaves deciduous; petioles 15–33 mm long, shallowly canaliculate on the adaxial surface, sparsely to evenly hirsute; blades obovate or ovate to elliptic, (5–)8–14.5 cm long, (3–)5–7.5 cm wide, the apex acuminate or nearly acute, the base acute, sometimes asymmetrical, the margin entire, the adaxial surface scabrous, rough to the touch, the abaxial surface hirsute. Inflorescences terminal, condensed and nearly umbellate, generally less than 1 cm long. Flowers distylous; calyx tubular, 8–12 mm long, 4–4.8(–5.6) mm wide at the mouth, the ribs more or less obscured by the villous indument, the hairs translucent to silver-gray or golden, usually 5-lobed, the lobes uneven, deltate to shallowly triangular-acuminate, 1.3–2.5 mm long, 10-ribbed; corolla white, tubular with spreading lobes, (18–)21–25.5 mm long, 4–5-lobed, the lobes oblong to widely oblong, 7–9(–10.5) mm long, 5.3–8(–9) mm wide, the tube 5.5–8(–10) mm long; stamens 4–5, the filaments 12–16 mm long, the upper 5.5–10.5 mm free, glabrous, the anthers oblong, 2–3.5 mm long; ovary depressed ovoid, 1–1.5 mm long, 1–1.8 mm broad, glabrous; disc anular-crateriform, 1–1.6 mm tall, 1–2 mm broad, glabrous or sparsely ciliate; style in long-styled flowers 16–17 mm long, in short-styled flowers 7–8.2 mm long, the stylar branches 1–2.4 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid, 5–6 mm long, 4–5.5 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—*Cordia globulifera* is known only from the western Mexican states of Guerrero, Jalisco, and Michoacan where it occurs in dry forests and flowers during the driest part of the dry season. The apparently disjunct, northern population near Mazatlán in Sinaloa has not been collected for approximately 90 years, so it is questionable as to what its status is and whether it still exists.

Specimens examined: **MEXICO. Guerrero:** along Mexican Highway 51, 10 km SE of Ciudad Altamirano, elev. 340 m, *Miller & Tenorio 655* (MO). **Jalisco:** La Huerta, carretera Puerto Vallarta—Barra de Navidad, a ca. 15 km al NW de la Estación de Biología Chamela, *Lott & Atkinson 2784* (MO); 4–22 km NW of Río San Nicolas and 20–40 km SE of Tomatlán, elev. 25–75 m, *McVaugh 25275* (MICH). **Michoacan:** 15 km W of apatzingán on road to Buena Vista, elev. 450 m, *McVaugh 22881* (ENCB, MICH); 27 kn W of Huetamo de Nunez on dirt road to Nueva Italia, just W of Santa Rita, elev. 230 m, *Miller & Tenorio 660* (MEXU, MO, NY); along dirt road to Nueva Italia, 36 km W of Huetamo de Nunez, elev. 220 m, *Miller & Tenorio 662* (MEXU, MO, NY); along dirt road to Nueva Italia, 40 km W of Huetamo de Nunez, elev. 340 m, *Miller & Tenorio 663* (MEXU, MO); along the dirt road to Nueva Italia, 75 km W of Huetamo de Nunez, 16 km W of Quetzeria, elev. 350 m, *Miller & Tenorio 667* (MEXU, MO); along the dirt road between Huacana and Nueva Italia, 22 km N of Huacana, elev. 200 m, *Miller & Tenorio 671* (MEXU, MO, NY); along Mexican Highway 51, 25 km S of Nueva Italia, elev. 210 m, *Miller & Tenorio 672* (MEXU, MO, NY); cerca de Angamio, camino San Jeronimo-Churumuco, elev. 450 m, *Soto & Boom 2053* (MEXU); en Palo Pintada, 18 km al S de la desviación al Infernillo, elev. 450 m, *Soto & Boom 2062* (MEXU). **Sinaloa:** Mazatlán, *Ortega 5597* (K, MEXU, US); Mazatlán, Bellavista, *Ortega 6845* (BR, F).

Ivan Johnston (1950) described both *Cordia globulifera* and *C. nelsonii* both known to him only from the types, based on differences in length of calyx and corolla lobes, differences which have been obscured by additional collections. *Cordia globulifera* is an uncommon species of western Mexico that is infrequently collected, largely

because it flowers in the middle of the dry season when most other species are completely dormant. It can be recognized by its parallel-sided corolla lobes and condensed, nearly umbellate inflorescences, and it flowers while leafless.

8. Cordia goeldiana Huber, Bol. Mus. Goeldi Hist. Nat. Ethnogr. 6:89. 1910. (**Fig. 4**). *Gerascanthus goeldiana* (Huber) M. Kuhlm. & Mattos, Loefgrenia 47:2. 1970. *Gerascanthus goeldianus* (Huber) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: BRAZIL. PARÁ: Peixeboi, railroad between Pará and Braganca, 23 Sep 1907, *Goeldi s.n. (MG8319)* (HOLOTYPE: G-DEL; ISOTYPES: B, BM, F, GH, K, MG, RB, S, U, US).

Tree to 30 m tall, the branches glabrous, often lustrous, the axillary buds densely puberulent, at least when young. Leaves deciduous; petioles (13–)20–40(–48) mm long, narrowly canaliculate on the adaxial surface, glabrous; blades narrowly elliptic or lanceolate to elliptic-oblong or obovate, (7–)8–16 cm long, 2.5–7 cm wide, the apex narrowly acuminate to obtuse and abruptly acuminate, the base cuneate to decurrent or acute, the margin entire, the adaxial surface glabrous and lustrous, the abaxial surface glabrous. Inflorescences terminal, a panicle or cluster of small panicles, 7–12 cm long, 12–17 cm broad, the branches glabrous to sparsely puberulent but becoming densely puberulent near the tips. Flowers distylous, sessile, borne with the leaves; calyx tubular, 8.5–10.5 mm long, 5–6.3 mm wide at the mouth, the lobes 2–3, uneven, widely ovate, 2.8–3.8 mm long, lightly striate, sometimes not very evidently so, ribs not present smooth in bud, glabrous to short, brown tomentulose or granular puberulous; corolla marcescent, white, funnelform 22–30 mm long, 5-merous, the lobes oblong, parallel-sided, 11.5–17 mm long, 6.5–10 mm wide, the apex acute and sometimes uneven, the tube 5–7 mm long; stamens 5, the filaments 10.5–19 mm long, the upper 5.5–12 mm free, puberulent to villous at and just above the point of insertion, the anthers oblong, 2.4–4.3 mm long; ovary obloid to ovoid-obloid, 1–2.6 mm long, 1.2–2 mm broad, glabrous; disc indistinct to anular and ca. 0.8 mm tall, 1.2–1.5 mm broad, glabrous; style 7–18 mm long, the stigma lobes clavate. Fruits not seen.

Distribution and habitat.—Cordia goeldiana is apparently localized near the mouth of the Amazon along the banks of its major tributaries and in adjacent French Guiana and Guyana. Little is known about its ecological preferences, but it presumably grows on tierra firme well back from the river banks.

Specimens examined: **BRAZIL. Amapa:** Río Amapari, Serra do Navid, elev. 70–300 m, *Cowan 38447* (F, NY, US); Río falsino, approx. 10 km upstream of confluence of Río Arauari, west bank, *Rabelo 2378* (F, MO, NY). **Amazonas:** Reserva Florestal Ducke, Manaus-Itacoatiara, km 26, *Assuncao 642* (MO). **Para:** Belém, *Ducke 788* (F, MO, NY, US); *Ducke 2345* (F, NY, US); Río Xingu, inter Boa Pista et Altamira, *Ducke 11407* (US); Belém, I.A.N. mata do Cafezal, *Pires 1785* (NY); *Pires 1786* (NY); Km 8.3–11.5, line SW of Ilha de Breu, *Prance et al. 1492* (F, MO, NY, US). **Rondonia:** Basin of Río Madeira, Km 12, road Guajará—Mirim to Abuña, *Prance et al. 6804* (MO, NY). **FRENCH GUIANA:** Saul, Route de Belizon, between Saul and Eaux Claires, elev. 200–300 m, *Mori 21614* (MO; NY). **GUYANA:** Station des Nouragues, bassin de l'Arataye, *Sabatier & Prévost 2695* (MO).

Cordia goeldiana can be distinguished by its glabrous leaves, parallel-sided corolla lobes, and calyx that lacks evident ribs. It is unusual in its occurence in wet forests near the mouth of the Amazon.

9. Cordia gracilipes I.M. Johnst., J. Arnold Arbor. 31:186. 1950. (**Fig. 3**). *Gerascanthus gracilipes* (I.M. Johnst.) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: MEXICO. GUERRERO: Campo Morado to Pueblo Viejo, tree 10 m. tall on rocky hillside, fl. white, 9 Nov 1939, *G.B. Hinton 14826* (HOLOTYPE: GH; ISOTYPES: DS, F, MEXU, MICH, NY, POM, U, UC, US).

Tree to 10 m tall, the twigs glabrous, with small elliptic lenticels, less than 1 mm long. Leaves deciduous; petioles (12–)15–25(–28) mm long, canaliculate to flattened on the adaxial surface, glabrous to villous; blades narrowly elliptic to elliptic to obovate, (5.5–)6–9(–10.8) cm long, 2.3–4(–4.5) cm wide, the apex acuminate to acute, the base acute, the margin entire, the upper surface glabrous, the lower surface sparsely pilose, most of the hairs restricted to the veins. Inflorescences terminal, paniculate or clusters of narrow panicles, 6–13 cm long, 6–16 cm broad, the branches of the inflorescence covered with a very short, dense, curly, dark-brown tomentum. Flowers distylous, short pedicellate or nearly sessile; calyx tubular, 9–11 mm long, 4–5 mm wide at the mouth, (8–)10-ribbed, puberulent, the hairs dense, curly, very short, dark-brown, (4–)5-lobed, the lobes shallowly triangular; corolla white, funnelform, 22–25 mm long, 5-lobed, the lobes widely depressed ovate, 7–8 mm long, 10–11 mm wide, the tube 9–11 mm long; stamens 5, the filaments 15 mm long, the upper 9 mm free, glabrous, the anthers oblong, 2 mm long; ovary cylindrical, 1 mm long, 1 mm broad, glabrous; style 19 mm long, the stylar branches 2.5 mm long, the stigma lobes clavate. Fruits unknown.

Distribution and habitat.—This species is still known from only the type collection made more than 80 years ago in central Guerrero in the dry forests of the hills of western Mexico.

Cordia gracilipes is still known only from the type collection made in a poorly collected area of central Guerrero. It is a distinctive species that can be recognized by its long-petiolate, glabrous leaves, calyx with short black hairs, and a ciliate nectariferous disc.

10. Cordia guerckeana Loes., Verh. Bot. Vereins Prov. Brandenburg 55:186. 1913. (**Fig. 5**). *Gerascanthus guerkeanus* (Loes.) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: MEXICO. OAXACA: Cañada above Totolapan, 3 Jan 1896, *E. Seler 1636* (LECTOTYPE: B; ISOLECTOTYPES: GH, K, NY).

Small tree or shrub to 6 m tall, the twigs glabrous, with circular to elliptic lenticels. Leaves deciduous; petioles (3–)5–10(–12) mm long, flattened to slightly canaliculate on the adaxial surface, short tomentose, the hairs somewhat deciduous, yellow-brown; blades coriaceous, elliptic to obovate, (3.7–)5.6–9.4(–10.5) cm long, (1.6–)2.8–5.6(–6.7) cm wide, the apex obtuse to rounded, the base acute or less commonly obtuse to rounded, the margin entire, the adaxial surface glabrous, the abaxial surface tomentose to arachnoid, the hairs wavy, thin, yellow-brown. Inflorescences terminal, paniculate, 6–15 cm long, 5–10 cm broad, the branches downy-tomentose, the hairs short, yellow-brown. Flowers distylous, short pedicellate to sessile; calyx tubular, 11–13 mm long, 3–4 mm wide at the mouth, pubescent, the hairs appressed, 10-ribbed; corolla white, funnelform, 19–22 mm long, 5-merous, the lobes widely depressed ovate, 5–6 mm long, 7–9.5 mm wide, the tube 9–13 mm long; stamens 5, the filaments 15–18 mm long, the upper 6–10.5 mm free, glabrous, the anthers oblong, 2–2.5 mm long; ovary broadly ovoid, 1–1.5 mm long, ca. 1 mm broad, glabrous; disc depressed ovoid, ca. 1 mm tall, 1 mm broad, glabrous; style 11–19 mm long, the stylar branches 3.5 mm long, the stigma lobes clavate. Fruit unknown.

Distribution and habitat.—*Cordia guerckeana* is known only from a small area extending into the dry forested hills inland from Tehuantepec in the Mexican state of Oaxaca from sea level to nearly 1,000 m in elevation.

Specimens examined: **MEXICO. Oaxaca:** hills E of Tehuantepec, *Alexander 108* (NY); plain of Tehuantepec, *Alexander 173a* (NY); distrito de Tiacolula, 6 km al NE de Totolapan, Carretera Veg, elev. 800 m, *García-Mendosa et al. 2824* (MO); Mpio. Santa María Huatulco, terminación de pavimento de la carretera a Salina Cruz, ca. 50 km al E del entronqúe con la carretera Pochutla Puerto Angel, elev. 100 m, *Koch et al. 79547* (MO, NY); Tehuantepec, subida a las Ruinas del Cerro Guiengola, *Leticia Torres et al. 619* (MO); Plantavinta, *Liebmann sn.n* (F); San Carlos, *Liebmann 12729* (C, F, MO, UC, US); Puerto San Bartolo Río Hondo, *MacDougall 9303* (MEXU); Tehuantepec, Cerro Lieza, 2 km a NW de Tehuantepec, *Martínez 756* (MO); Totolapan, in canyon directly above town, elev. 940 m, *Miller & Tenorio 506* (MEXU, MO); Puerto San Bartolo, Río Hondo, *Miranda 9303* (US); Cañada above Totolapan, *Seler & Seler 1636* (K, NY).

The leaves of *Cordia guerckeana* are some of the most distinctive in the section due to the presence of an arachnoid-tomentose undersurface. This species apparently occurs only in western Mexico just inland from Tehuantepec, in the drainage of the Río Tehuantepec on hillsides above the river.

11. Cordia iguaguana Melch. ex I.M. Johnst., J. Arnold Arbor. 33:63. 1952. (**Fig. 4**). *Gerascanthus iguaguanus* (Melch. ex I.M. Johnst.) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: PERU. CAJAMARCA: Prov. Jaen, Jaen, 700–800 m, Apr 1912, *Weberbauer 6213* (HOLOTYPE: GH; ISOTYPES: F, US).

Tree to 20 m tall, the twigs glabrous or very short puberulent. Leaves deciduous; petioles (9–)12–22 mm long, canaliculate on the adaxial surface, glabrous or with a few scattered short hairs, or less commonly very shortly puberulent; blades lanceolate to ovate, (6.4–)10–15 cm long, (2.5–)4–5 cm wide, the apex attenuate or acuminate to acute, the base obtuse, the margin entire, the adaxial surface glabrous, but with scattered cystoliths, the abaxial surface glabrous, often with sparse, short, appressed hairs on the major veins. Inflorescences terminal, paniculate, often with a few small leaves scattered among the lower inflorescence branches, the branches short brown tomentulose to glabrous. Flowers distylous; calyx tubular, 9.5–11 mm long, 2.5–3 mm wide at the mouth, 10-ribbed, 3–5-lobed, the lobes uneven, obtuse to triangular, 1–2 mm long; corolla white, 21–23 mm long, funnelform, 5-lobed, the lobes broadly ovoid, 5–8 mm long, 8–10 mm wide, the tube 8–8.5 mm long; stamens the same number as the corolla lobes, the filaments 14–16 mm long, the upper (2–)7–9 mm free, glabrous, the anthers oblong, 1.5–3 mm long; ovary lanceoloid, 1–1.5 mm long, 0.6–1 mm broad, glabrous; disc

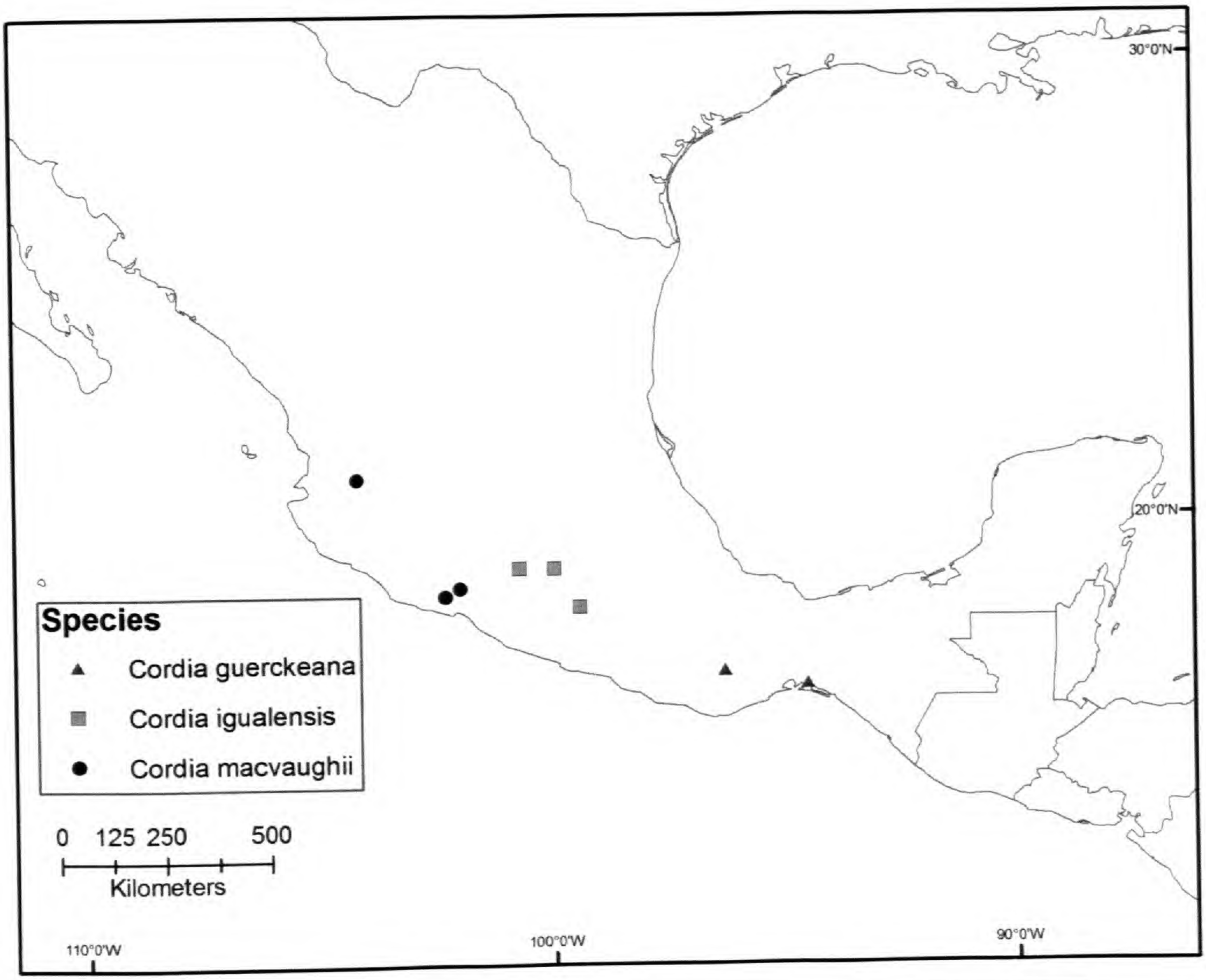


Fig. 5. Distributions of *Cordia guerckeana*, *C. igualensis*, and *C. macvaughii*.

not distinct from the ovary; style 6–11 mm long, the stylar branches 2–3 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ovoid, 7–8 mm long, 3–4 mm broad, one-seeded, the endocarp wall hard and bony.

Distribution and habitat.—This species is known from dry forests in the northern Peruvian states of Amazonas, Cajamarca, and San Martin.

Representative specimens examined: **PERU. Amazonas:** Prov. Luya, Km 276, entre Jazán y Bagua Grande, elev. 800–900 m, *Ferreyra 15632* (MO). **Cajamarca:** San José de Lourdes, Nambacasa, elev. 1,650 m, *Campos & Campos 4872* (NY); San Ignacio, Chirinos, entre Perico y Puerto Chuchuhuani, elev. 550–650 m, *Campos & López 4962* (NY); Prov. Jaén, Jaén, carretera hacia "Los Naranjas," elev. 760 m, *Díaz 2074* (NY); Prov. Jaén, in the forest, elev. 500 m, *Woytkowski 5599* (MO, US); Prov. Jaén, Jaén—San Ignacio road, N of Jaén, valley of Río Chinchipe, S of Tamborapa, elev. 700 m, *Gentry 61020* (NY); Prov. Jaén, Shumba, desvio al oueste de la carretera entre Jaén y San Ignacio, *Sanchez Vega 3934* (NY); along road Bagua Grande and Pedro Ruiz, elev. 500–1,000 m, *van der Werff 14638* (NY). **San Martin:** 31 km S of Tarapoto, dry foresteed slopes overlooking Río Huallaga, elev. 350 m, *Gentry et al. 37700* (MO).

Cordia iguaguana is an uncommon species of northern Peru that is distinctive in its glabrous leaves and calyx and its hard, bony-walled fruits.

12. Cordia igualensis Bartlett, Contr. Gray Herb. 36:632. 1909. (**Fig. 5**). *Gerascanthus igualensis* (Bartlett) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: MEXICO. GUERRERO: Iguala Canyon, 28 Dec 1906, *C.G. Pringle 13912* (HOLOTYPE: GH; ISOTYPES: ENCB, L, MEXU, US).

Tree to 15 m tall, the twigs glabrous. Leaves deciduous; petioles (8–)13–19(–28) mm long, canaliculate on the adaxial surface, nearly glabrous with sparse, short, appressed hairs; blades narrowly elliptic to ovate or slightly

oblanceolate, (5.7–)8.3–16(–17.5) cm long, (1.6–)4–6(–9) cm wide, the apex acute to acuminate, the base acute to obtuse, the margin entire to slightly undulate, the adaxial surface glabrous, the abaxial surface glabrous or nearly so with stiff, short hairs on major veins. Inflorescences terminal, cymose-paniculate, 5–13.5 cm broad, the branches glabrous except near the ends which are densely covered with short, interwoven, black hairs. Flowers distylous, on pedicels to 2 mm long; calyx tubular, 6.5–8 mm long, ca. 3 mm wide at the mouth, slightly puberulent, the hairs short, black, mostly restricted to the grooves between the ribs, 10-ribbed, nearly truncate with 5 small teeth; corolla white, funnelform, 23–34 mm long, 5-merous, the lobes depressed ovate to widely depressed ovate, 6.5–8 mm long, 8.5–10 mm wide, the tube 8–9 mm long; stamens 5, the filaments 14–17 mm long, the upper 7–10 mm free, glabrous, the anthers oblong, 2–3 mm long; ovary broadly obovoid to broadly oblong, 1–1.5 mm long, 1–1.7 mm broad, glabrous; disc depressed obovoid, 0.5–1 mm tall, ca. 1 mm broad, glabrous; style 9–16 mm long, the stylar branches 1–4 mm long, the stigma lobes thickened to flattened. Fruits unknown.

Distribution and habitat.—This rarely collected species is known from a limited area in western Mexico near the intersection of the borders of the states of Guerrero, México, and Michoacán.

Specimens examined: **MEXICO. Guerrero:** Cañon del Zopilote, cerca Venta Vieja, en Barranca, Km. 234 carretera Acapulco, *Miranda 9248* (MEXU); Cañon del Zopilote, cerca Venta Vieja, laderas muy alteradas, cerca Zumpanga, *Miranda 9280* (MEXU). **Mexico:** Dist. Temascaltepec, Acatitlán, *Hinton 3176* (F, G, GH, K, MO, NY). **Michoacan:** 9 km al NW de Tayzupa hacia Coahuyana, *Soto Nuñeza & Torres 2785* (MO).

Cordia igualensis can be recognized by its cymose-paniculate inflorescence, depressed ovate corolla lobes, and 6.5–8 mm long calyx with short black hairs. It is an uncommon species of central Guerrero that flowers at the onset of the dry season, in November and December.

13. Cordia insignis Cham., Linnaea 8:122. 1833. (**Fig. 4**). *Gerascanthus insignis* (Cham.) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: BRAZIL: Minas Gerais, *Lhotzky s.n.* (HOLOTYPE: B). *Lithocardium insigne* (Cham.) Kuntze, Revis. Gen. Pl. 2:977. 1891.

Cordia haenkeana Mez, Bot. Jahrb. Syst. 12:560. 1890. *Gerascanthus haenkeanus* (Mez) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: PERU?: *Haenke s.n.* (HOLOTYPE: M). Although the type is reported from Peru, this seems unlikely as the species have never been collected there.

Cordia insignis var. *glabrifolia* I.M. Johnst., Contr. Gray Herb. 92:11. 1930. TYPE: BRAZIL: Matto Grosso, Jul 1892, *Kuntze s.n.* (HOLOTYPE: NY; ISOTYPE: B).

Cordia jucunda Moore, Trans. Linn. Soc. ser. 2, 4:401. 1893. TYPE: BRAZIL: Matto Grosso, *Leeson s.n.* (HOLOTYPE: BM; ISOTYPE: A).

Cordia martii A. DC., Prodr. 9:471. 1845. TYPE: BRAZIL: in montibus Cyuabensibus, *Herb. Fl. Bras. n. 269* (ISOTYPE: K).

Cordia nettoana Taub., Bot. Jahrb. Syst. 15, Beibl. 38:11. 1893. *Gerascanthus nettoanus* (Taub.) Borhidi, Acta Bot. Hung. 34:398. 1988. TYPE: BRAZIL. RIO JANEIRO: Cabo Frio, *Glaziou 11283* (HOLOTYPE: B; ISOTYPES: K, P).

Shrub to 3(–4) m tall, from a thickened underground xylopodium, in some cases the aerial stems annual, the twigs puberulent to tomentulose when young, later glabrous and waxy. Leaves deciduous; petioles (2–)12–23(–34) mm long, canaliculate to flattened on the adaxial surface; blades widely elliptic to elliptic or occasionally slightly ovate or obovate, (7–)12–22(–30) cm long, (4–)7–11(–17) cm wide, the apex obtuse to rounded or occasionally acute, the base rounded to obtuse, the margin entire, the adaxial surface rugose-bullate, glabrous and lustrous with only a few, widely-scattered hairs, the abaxial surface with the veins distinctly raised in a reticulate pattern, coarse pubescent along the veins. Inflorescences terminal, cymose-paniculate to cymose, 6–11(–23) cm long, (3.5–)6–11(–26) cm broad, the branches tomentulose, the peduncle (2–)5–14 cm long. Flowers distylous, the buds prominently apiculate; calyx tubular, 15–25 mm long, 4–6 mm wide at the mouth, prominently 10-ribbed, densely brown puberulent, 3–5-lobed, the lobes uneven, 2–3 mm long; corolla white to yellow, 33–40 mm long, 5-lobed, the lobes widely ovate, 8–10 mm long 8–10 mm wide, the tube 18–27 mm long; stamens 5, the filaments 16–26 mm long, the upper 5–7 mm free, the anthers oblong, 3–4 mm long; ovary ovoid to ellipsoid, 2–5 mm long, the style 15–25 mm long, the stylar branches 6–10 mm long, the stigmas clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid, 10–15 mm long, 5–6 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—This species occurs in Cerrado and dry forests from the western part of Bahía to central Bolivia up to 500 m in elevation.

Representative specimens examined: **BOLIVIA. Beni:** Itenez, Parque Nacional Noel Kempff Mercado, Serrania San Simon, entre Remanso Y San Simon, elev. 250 m, *Arroyo P. et al. 2604* (MO, USZ). **Santa Cruz:** Prov. Nuflo de Chavez, Consepción, *Krapovickas & Schinini 31914* (MO). **BRAZIL. Bahia:** Brumado, Baixa dos Flores, *Sobrinhi 255* (US). **Goias:** 100 km S of Guara, along Belém—Brasilia highway, elev. 500–800 ft, *Maguire et al. 56118* (NY, US). **Mato Grosso:** Mpio. da Chapada dos Gjuimaraes, Rí Mutuca, MT251, 30 km NNE of Cuiabá, *Mori et al. 16707* (MO, NY).

Cordia insignis is a very distinctive species of the Brazilian cerrado that is unusual in being a shrub, apparently growing from an enlarged root and at least in some cases the aerial stems are annual in duration, and also in its large, distinctly bullate leaves.

14. Cordia latiloba I.M. Johnst., Contr. Gray Herb. 92:9. 1930. (**Fig. 6**). *Gerascanthus latilobus* (I.M. Johnst.) M. Kuhlm. & Mattos, Loefgrenia 47:2. 1970. TYPE: BRAZIL: Río Janeiro, *Glaziou 1106* (HOLOTYPE: K; ISOTYPES: C, P, S).

Tree, the twigs glabrous. Leaves deciduous; petioles 15–45(–60) mm long, canaliculate on the adaxial surface, glabrous; blades elliptic to elliptic-oblong, 4–15 cm long, 2.5–7 cm wide, the apex abruptly short acuminate or acute, the base cuneate to obtuse, the margin entire, the adaxial surface glabrous, the abaxial surface glabrous. Inflorescences terminal, paniculate, 4–15 cm long, the branches glabrous or minutely brown puberulent or glandular. Flowers distylous; calyx tubular, 8–12 mm long, 2–3 mm wide at the mouth, 10-ribbed, glabrous or sparsely glandular-puberulent, 2–3-lobed, the lobes uneven, deltate or rounded to obtuse, 1.5–3 mm long; corolla white, funnelform, 25–33 mm long, 5-lobed, the lobes deltate to ovate, 5–11 mm long, 6–12 mm wide, the apex acute, the tube 10–12 mm long; stamens the same number as the corolla lobes, the filaments 18–25 mm long, the upper 8–14 mm free, with short stiff hairs at the point of insertion, the anthers oblong, 2–3 mm long; ovary ovoid, 1–1.5 mm long, 0.8–1.2 mm wide, glabrous; style ca. 20 mm long, the stylar branches 3–5 mm long, the stigma lobes clavate. Fruits enclosed in the persistent calyx and corolla, brown, ca. 12 mm long, 3.5 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—This species is reported only with imprecise localities in the area surrounding Río de Janeiro but has not been collected for more than one hundred years.

Specimens examined: **BRAZIL. Rio De Janeiro:** Río Janeiro, *Riedel s.n.* (NY, S).

Cordia latiloba is a rare species of southern Brazil that is very distinctive in its deltate corolla lobes with an acute apex.

15. Cordia macrantha Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:215. 1921. (**Fig. 6**). *Lithocardium macranthum* (Chodat) Kuntze, Revis. Gen. Pl. 2:4387. 1891. TYPE: ECUADOR. GUAYAS: Guayaquil, *Ruiz & Pavon 229* (HOLOTYPE: B; photo: US).

Tree to 10(–18) m tall, the twigs glabrous and waxy. Leaves deciduous; petioles (7–)14–31(–41) mm long, broadly canaliculate on the adaxial surface, puberulent or sparsely strigillose to glabrous; blades widely elliptic to elliptic-ovate, 10–30 cm long, 4.5–15.3 cm wide, the apex obtuse to rounded and often abruptly acuminate, the base obtuse, the margin entire, the adaxial surface glabrous, the abaxial surface villous to sparsely pubescent. Inflorescences terminal, cymose-paniculate or a cluster of panicles, 6–18 cm long, 9–16 cm broad, the branches puberulent above, often glabrous near the base. Flowers distylous, sessile; calyx tubular, 18.5–20 mm long, 6.4–6.9 mm wide at the mouth, prominantly 10-ribbed, densely puberulent, 3-lobed, the lobes deltate-acuminate, 2–2.2 mm long; corolla white, tubular with spreading lobes, 40–41.5 mm long, 5-merous, the lobes very broadly ovate to depressed ovate, rounded at the apex, 10.3–14 mm long, 12.5–14.5 mm wide, the tube 17–19 mm long; stamens 5, the filaments 23–28 mm long, the upper 11–13.5 mm free, pubescent at the point of insertion, the anthers oblong, 3.3–3.5 mm long; ovary very broadly ovoid, 1.5 mm long, 1.8 mm broad, the disc anular, 0.9 mm tall, 1.2 mm broad, glabrous; style 20–25 mm long, the stylar branches 3 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid, 9–11 mm long, 4.4.5 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—This species is endemic to Ecuador where it occurs in dry forests on the coastal plain up to 500 m in elevation.

Specimens examined: **ECUADOR. El Oro:** at Arenillas 6 km S, *Little 6708* (F, NY, US). **Guayas:** Chongón, *Asplund 7673* (NY, US); between Nobol and Isidro Ayora, *Asplund 16659* (F, NY); Capeira, Km 21, Guayaquil to Daule, elev. 20–200 m, *Dodson & Dodson 11356* (MO); Capeira,

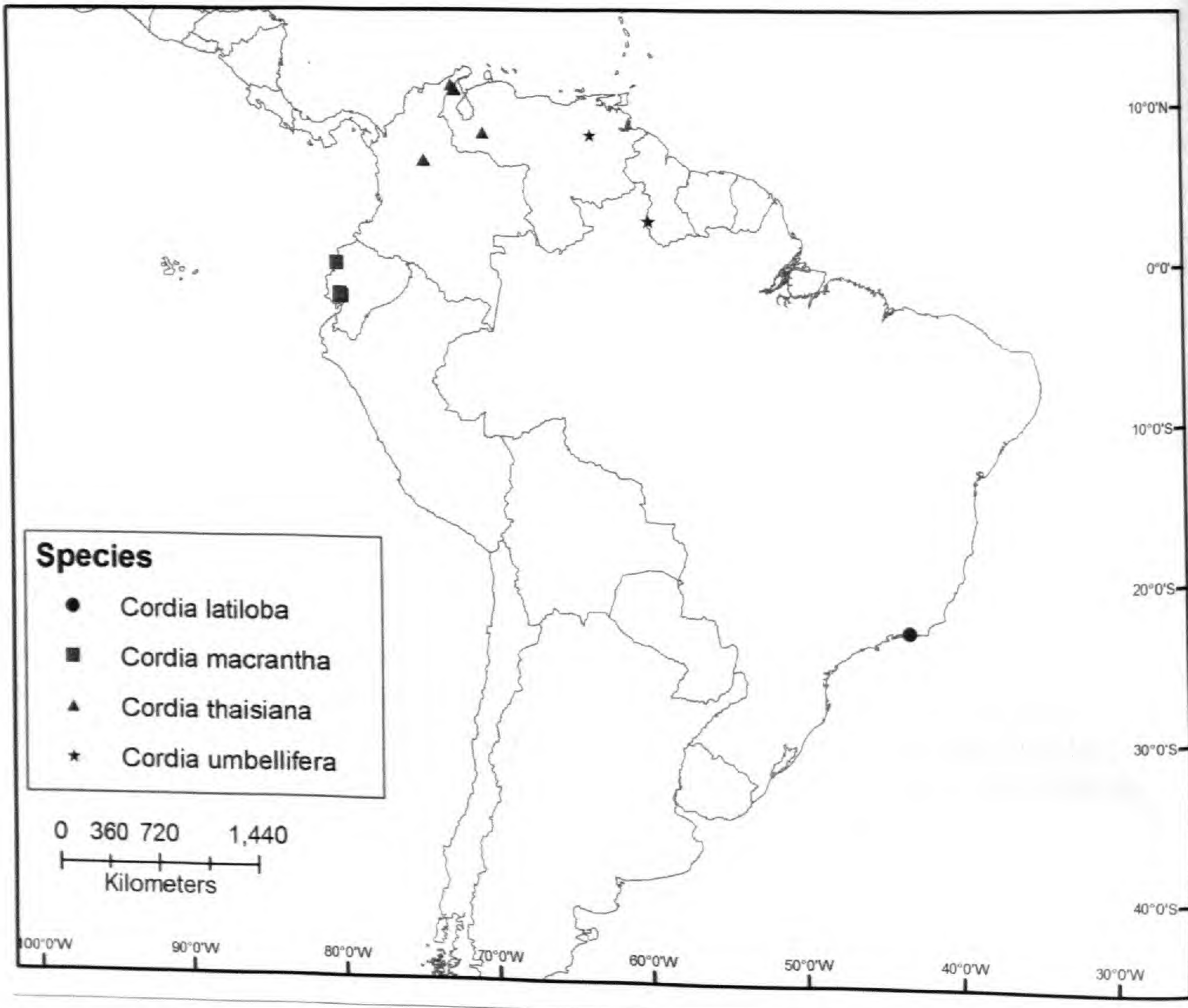


FIG. 6. Distributions of *Cordia latiloba*, *C. macrantha*, *C. thaisiana*, and *C. umbellifera*.

Km 21, Guayaquil to Daule, elev. 20–200 m, *Dodson & Dodson 11453* (MO); Capeira, Km 21, Guayaquil to Daule, elev. 20–200 m, *Dodson & Gentry 13849* (MO); Capeira, Km 21, Guayaquil to Daule, elev. 20–200 m, *Dodson & Gentry 13850* (MO); Capeira, 22 km N of Guayaquil on road to Daule, elev. 20–150 m, *Gentry & Dodson 54795* (MO); Capeira, 22 km N of Guayaquil on road to Daule, elev. 20–150 m, *Gentry & Dodson 54796* (MO); Guayaquil Canton, Cerro Azul, carretera a Salinas, Km 13, elev. 350–500 m, *Rubio et al. 1950* (MO, NY, QCNE); Guayaquil, *Ruiz & Pavon 16/97* (MO photo of M specimen). **Manabi:** Pedernales, Estación Biológica Lalo Loor, a 22 km de la costa, elev. 125 m, *Cevallos & Neill 208* (MO, QCNE).

Cordia macrantha is a distinctive species found in the dry forests of western Ecuador that is easily recognized by its unusually large leaves and flowers, cymose-paniculate inflorescence, and glabrous calyx.

16. Cordia macvaughii J.S. Mill., Syst. Bot. 11:179. 1986. (**Fig. 5**). TYPE: MEXICO. JALISCO: steep hillsides W of Magdalena, 15 km above Plan de Barranca, elev. 1,250 m, *R. McVaugh 23505* (HOLOTYPE: MICH).

Tree 6–10 m tall, the twigs glabrous. Leaves deciduous; petioles 18–26 mm long, broadly canaliculate on the adaxial surface, puberulent; blades elliptic to widely elliptic, 13.3–13.9 cm long, 6.6–10.4 cm wide, the apex obtuse to rounded, the base obtuse to acute, the margin entire, the adaxial surface glabrous to strigillose, the abaxial surface dcensely puberulent. Inflorescences terminal, paniculate, 15–22 cm broad, the branches velutinous. Flowers distylous, short pedicellate, the pedicels 1.2 mm long; calyx tubular 7–10 mm long, 2.5–4 mm wide at the mouth, nearly truncate with 5 small acuminate teeth, these 0.5–1 mm long, prominently 10-ribbed, velutinous; corolla white, funnelform, 1.8–2.3 cm long, 5-merous, the lobes very widely ovate to widely depressed ovate, 6–7 mm long, 6–9 mm wide, the tube 8–11 mm long; stamens 5, the filaments 11–21 mm long,

the upper 5.5–11 mm free, the lowest portion of the free filaments thickened, pubescent at the point of insertion, the anthers oblong, 2–3 mm long; ovary cylindrical, ca. 1 mm long, 1 mm broad, glabrous; style 10.5–17 mm long, the stylar branches 1–2.5 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, wall thin, fibrous, marure fruits not seen.

Distribution and habitat.—This species is endemic to western Mexico, where it occurs in dry forests of Jalisco and Michoacán between 600 and 1,300 m in elevation.

Specimens examined: **MEXICO. Jalisco:** between La Venta de Nochititlic and Barran quitas, on sides of barranca in heavily wooded areas along the Tepoic-Guadalajara Highway, elev. 950 m, *McVaugh 12044* (GH, MEXU, MICH). **Michoacan:** Hills in deciduous forest now nearly leafless, between Río Tepalcatepec and Arteaga, along the highway south from "Cuatra Caminos" (3 km S of Nueva Italia and 30 im E of Apatzingan), 40 im N of Arteaga, elev. 700 m, *McVaugh 22535* (ENCB, MICH); along Mexican Highway 37, 13 km S of the turnoff to Infernillo, at KM 234, elev. 660 m, *Miller & Téllez 3080* (MEXU, MO); along Mexican highway 37, 14 km S of the turnoff to Infernillo, at KM 235, elev. 660 m, *Miller & Téllez 3082* (MEXU, MO, NY).

Cordia macvaughii is a well-marked species characterized by a large paniculate inflorescence with branches covered with downy velutinous pubescence, corolla lobes that are wider than long, the lack of long pubescence on the calyx, and rather large, broad leaves. It appears to flower while leafless, shortly after the leaves are shed.

17. Cordia megalantha S.F. Blake, Proc. Biol. Soc. Washington 36:200. 1923. (**Fig. 2**). *Cordia macrantha* S.F. Blake (not Chodat), Contr. U.S. Natl. Herb. 24:19. 1922. *Gerascanthus megalanthus* (S.F. Blake) Borhidi, Acta Bot. Hung. 34(3–4):398. 1988. TYPE: GUATEMALA: Izabal, Quebradas, 18 May 1919, *S.F. Blake 7498* (HOLOTYPE: US; ISOTYPE: G).

Tree to 30(–60) m tall, twigs glabrous, lenticellate. Leaves deciduous; petioles (8–)11–33(–55) mm long, canaliculate on the adaxial surface, glabrous; blades elliptic to obovate or rarely ovate, (4.6–)6–19(–21) cm long, 3–8(–12.6) cm wide, the apex acute to acuminate or rarely obtuse, the base acute or rarely obtuse to rounded, the margin entire, the adaxial surface glabrous, the abaxial surface glabrous. Inflorescences terminal, paniculate, to 22 cm long, 30 cm broad, the main branches glabrous, puberulent at the tips. Flowers distylous, on pedicels 2–5(–10) mm long; calyx tubular, (8.5–)9–10(–11) mm long, 4–5.5 mm wide at the mouth, striate to 10–20-ribbed, glabrous to puberulent, the hairs dark brown, unevenly lobed, tearing upon dehiscence or dehiscing circumscissilly; corolla white, funnelform, 28–43(–50) mm long, 5(–6)-lobed, the lobes deltate to ovate, acute at the apex, (8.5–)11–13(–18) mm long, (8–)10–12.5 mm wide, the tube 7–9(–11.5) mm long; stamens 5(–6), the filaments 14.5–19 mm long, the upper 5–10(–13) mm free, pubescent at the point of insertion and frequently over the entire free portion, the anthers oblong, 2–2.6(–4) mm long; ovary ovoid to conical, 1.3–2.5(–4) mm long, 1–2 mm broad, glabrous; disc depressed obovoid, 0.5–1 mm tall, 1–2 mm broad, glabrous to ciliate; style (7.5–)16–19 mm long, glabrous or with a few scattered hairs, the stylar branches 3–4.5 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid to narrowly ellipsoid, 8–12 mm long, 4–6 mm broad, one-seeded, the wall thin, fibrous.

Distribution and habitat.—*Cordia megalantha* ranges from southern Mexico south through the lowland, Atlantic wet forests to Costa Rica and also occurs in a disjunct population in wet forests of the Pacific slope on the Osa Peninsula of Costa Rica and adjacent Burica Peninsula of Panama up to 1,000 m in elevation.

Representative specimens examined: **COSTA RICA. Alajuela:** San Carlos, Llanura de San Carlos, Las Marina, elev. 500 m, *Zamora et al. 1505* (CR, NY). **Guanacaste:** Parque Nacional Rincón de la Vieja Quebrada Leiva, a 1.5 km aguas arriba de la casa de Pedro Leiva, elev. 1,000 m, *Rivera 1267* (MO, NY). **Heredia:** La Selva, *Bawa 606* (MO). **Limon:** vicinity of Guapiles, elev. 300–500 m, *Standley 37249* (US). **Puntarenas:** Rincón de Osa, Osa Peninsula, *Liesner 1941* (MO). **San Jose:** Fila Bustamante, Hacienda Tiquires, Los Ayarales, al S. del Río Toqiores. e;ev/ 1.400 m, *Morales 4320* (CR, MO, NY). **GUATEMALA. Izabal:** lower Motagua, *Kuylen G147* (CFMR, F, GH, NY, US). **Peten:** La Libertad, *Lundell 3606* (F). **HONDURAS. Atlantida:** ca. 30 Km W of La Ceiba, elev. 40 m, *Stead S142* (FHO, MEXU, MO). **Yoro:** Road to El Progreso at 12 km from El Progreso, *Stead S198* (MO). **MEXICO. Chiapas:** Without definate locality, *Miranda 8324* (MEXU, US). **Oaxaca:** 5.8 km W de Esmeralda sobre terracería a Boca del Monte, 42 km N de Las Laguna, elev. 180 m, *Wendt et al. 3199* (MO, NY). **Veracruz:** Los Tuxtlas, *Gentry et al. 32294* (MO). **PANAMA. Chiriqui:** W of San Bartolo Limite near Costa Rican border, *Croat 22175* (MO).

Cordia megalantha is the tallest of all *Cordia* species, often exceeding 30 m, and occasionally reaching 60 m in height. It also has the largest flowers of any of the species of section *Gerascanthus*, with corollas 28–43(–50) mm long. It is easily recognized by its ovoid, apiculate buds and deltate corolla lobes with an acute apex. The calyx is generally not distinctly ribbed, but with 10–20 striations and the calyx opens by tearing into uneven lobes or it dehisces circumscissilly.

18. Cordia morelosana Standl., Contr. U.S. Natl. Herb. 23:1220. 1924. (**Fig. 7**). *Gerascanthus morelosanus* (Standl.) Borhidi, Acta Bot. Hung. 34:398. 1988. TYPE: MEXICO. MORELOS: near Cuernavaca, elev. 5,000 ft, 17 Mar 1899, *C.G. Pringle 8205 pro parte* (LECTOTYPE, here designated: US (flowering branch): ISOLECTOTYPES: ARIZ, ASU, BR, C, CAS, F, G, GH, IND, K, L, MEXU, MICH, MO NY, POM, UC, US). In naming this species, Standley designated *Pringle 8205* at US (sheet #3544555) as the holotype, but the specimen consists of flowering branches collected on 17 Mar 1899 and a branch with leaves collected on 29 Sep 1899, which represent two gatherings and are therefore an invalid type under articles 7 and 9 of the International Code of Botanical Nomenclature. Therefore, the flowering branches are here designated as the lectotype.

Spreading tree to 5(–8) m tall, the bark rough, dark gray, the twigs glabrous to hirsute. Leaves deciduous; petioles (3–)5–11(–16) mm long, flattened on the adaxial surface, hirsute; blades elliptic to widely elliptic, occasionally somewhat obovate, (2.4–)3–8(–9) cm long, (1.8–)2.5–5.7 cm wide, the apex obtuse to rounded, occasionally mucronulate, the base obtuse, often slightly assymetrical, the margin entire, the adaxial surface scabrous, the abaxial surface hirsute to less commonly strigose or scabrous. Inflorescences terminal, paniculate or condensed, to 3.5 cm long, 3.5 cm broad. Flowers distylous, sessile or on pedicels to 3(–7) mm long; calyx tubular, 11–14.5(–19) mm long, 4–5(–5.8) mm wide at the mouth, (2–)3–5-lobed, the lobes uneven, usually deltate-acuminate, 1.4–2.7(–3.5) mm long, 10-ribbed, the ribs more or less obscured by a villous indument, the hairs translucent or white to pale gray; corolla white, funnelform, (14–)27–33(–38) mm long, (4–)5–6(–8)-merous, the lobes widely depressed ovate to depressed ovate, (5.8–)7–10(–12.5) mm long, (7.6–)9–12.5(–14) mm wide, the tube (8.6–) 9–13(–15.7) mm long; stamens the same number as the corolla lobes, the filaments in long-styled flowers 11.5–16(–18) mm long, the upper 6–9 mm free, in short-flowered flowers (17.7–) 19–22(–25) mm long, the upper (9.6–) 10.5–12.5(–15) mm free, pubescent at the point of insertion of occasionally glabrous, the anthers oblong, 2.4–4 mm long; ovary depressed ovoid, 0.8–1.3 mm long, 1–1.8 mm broad, glabrous; disc annular-crateriform, 0.6–1.2 mm tall, 0.9–1.8 mm broad, glabrous to ciliate; style in long-styled flowers (15.5–)17–20 mm long, in short-styled flowers 8.7–13.6(–16) mm long, the stylar branches (1.5–)2.3–4(–5) mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid to narrowly ellipsoid, 7–8(–9.3) mm long, 2–4 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—*Cordia morelosana* is widespread in western and central Mexico in Guerrero, Jalisco, México, Michoacán, Morelos, and Puebla, where it occurs in dry forests and open areas from (340–)800–1,650 m in elevation.

Representative specimens examined: **MEXICO Guerrero:** 19 km S of Iguala on Mexican Highway 95 between Iguala and Chilpancingo, elev. 805 m, *Miller et al. 674* (MEXU, MO, NY). **Jalisco:** A 1.5 km al NE de Ojo de Agua, elev. 1,350 m, *Sousa et al.* 3854 (MO). **Mexico:** Nanchititla, *Hinton 3122* (GH, K). **Michoacan:** Along dirt road 18 km W of Nueva Italia, elev. 490 m, *Miller & Tenorio 673* (MO). **Morelos:** Barranca de San Geronimo, cerca de Tepoztlan, elev 1,900 m, *Rzedowski 22348* (ENCB, INIF, MICH). **Puebla:** 2 mi W of Acatlán, *Wiggins 13251* (DS, SD).

Cordia morelosana is reasonably widespread in western Mexico. It can be recognized by its calyx that is villous and dense enough to conceal the ribs, corolla lobes that are wider than long, and leaves with an obtuse to rounded apex. It ranges from Jalisco east to Puebla and south to Guerrero and Morelos at (340–)800–1,650 m in elevation and is probably most closely related to and confused with *C. sonorae*, a species that mostly occurs further north and from sea level to 600(–1,000) in elevation, but overlaps in range in Michoacán and Guerrero. Both species flower while leafless and although the two species are quite distinct, flowering specimens can be very difficult to distinguish. *Cordia morelosana* is a spreading tree that lacks a central leader, has fissured dark gray bark, an obtuse to rounded leaf apex, leaves that are scabrous on the upper surface, and calyces with villous indument that generally conceals the ribs, while *C. sonorae* is an upright tree with a distinct central leader, with smooth pale gray bark, leaves with an acute apex and glabrous upper surface, and a calyx that is pubescent to vulutinous, but generally not dense enough to conceal the ribs.

19. Cordia sonorae Rose, Contr. U.S. Natl. Herb. 1:106, t. 9. 1891. (**Fig. 7**). *Gerascanthus sonorae* (Rose) Borhidi, Acta Bot. Hung. 34:398. 1988. TYPE: MEXICO. SONORA: Alamos, 16–30 Sep 1890, *E. Palmer 376* (HOLOTYPE: US; ISOTYPES: GH, K, MICH, NY, US). *Cordia palmeri* Rose, Contr. U.S. Natl. Herb 1:t. 9. 1891. This name appears on the illustration for the publication of *Cordia sonorae* so it seems likely that Rose chose this name and had the plant illustrated but then realized that Watson had used the name for an earlier plant and had it changed in the text but not on the illustration which is clearly of the same species.

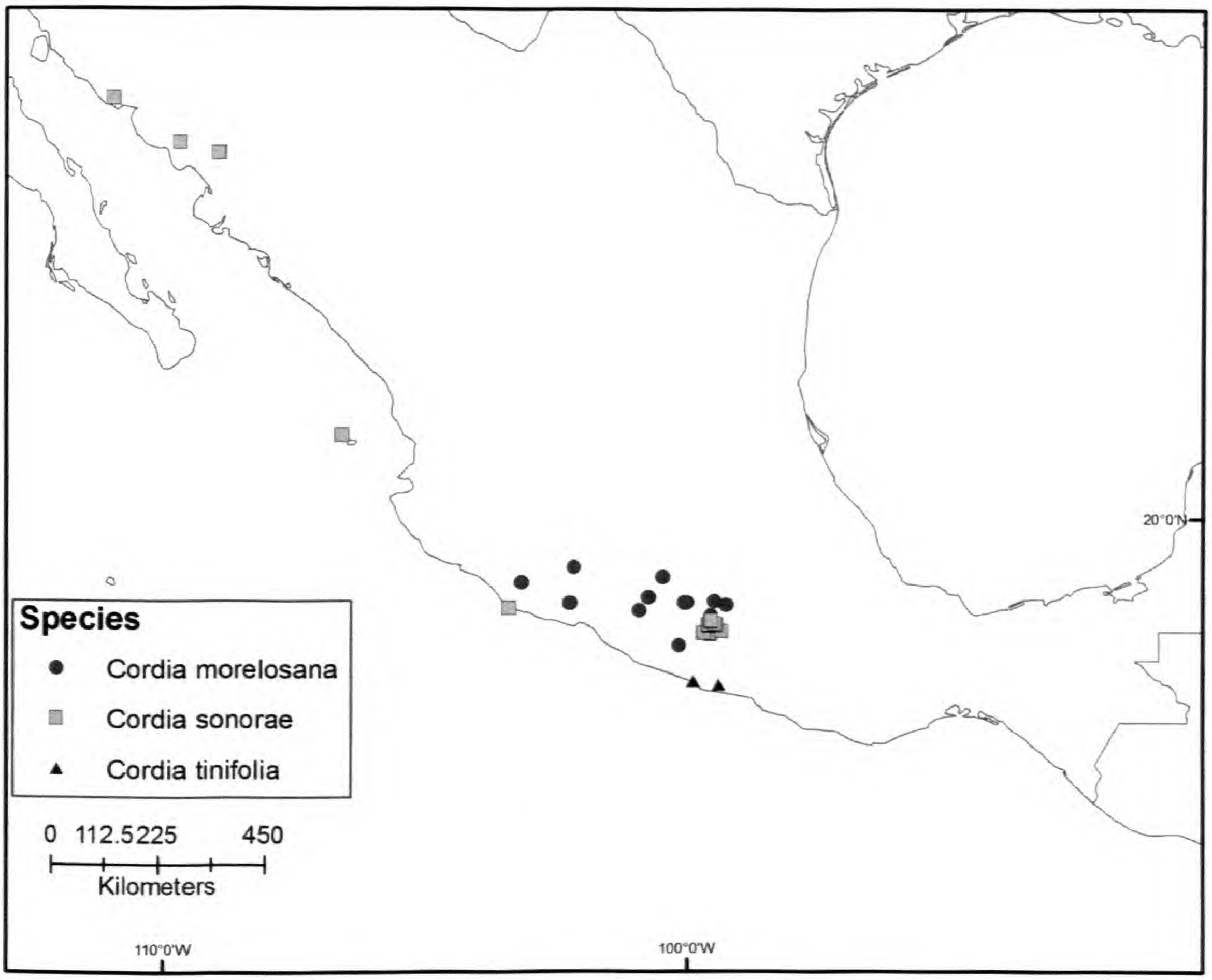


FIG. 7. Distributions of *Cordia morelosana*, *C. sonorae*, and *C. tinifolia*.

Erect tree to 5(–10) m tall, the bark light gray, smooth, the twigs sparsely strigillose or pubescent when young, later glabrous and sparsely lenticellate. Leaves deciduous; petioles (3–)6–14(–19) mm long, flattened or shallowly canaliculate on the adaxial surface, sparsely to evenly strigillose or pubescent with most of the hairs on the adaxial surface; blades usually elliptic, occasionally narrowly elliptic or ovate, (3–)4–13(–18) cm long, (1.4–)2.5–6.5(–8) cm wide, the apex usually acute, occasionally obtuse, the base obtuse to acute, the margin entire, the adaxial surface glabrous or nearly so, usually with numerous papillae, the abaxial surface glabrous or nearly so, often with scattered appressed hairs along the veins. Inflorescences terminal, solitary or clusters of sparsely branched panicles to 17 cm long, or condensed, often nearly umbellate, the branches villous to tomentose. Flowers distylous, sessile or on short pedicels to 3 mm long; calyx tubular, (10.6–)12.5–18(–20) mm long, (3–)4–5 mm wide at the mouth, 10-ribbed, pubescent or velutinous to occasionally villous, unevenly 3–5-lobed, the lobes deltate-acuminate, (1–)2–3(–4) mm long; corolla white, funnelform, 24–36 mm long, 5(–6)-merous, the lobes depressed ovate to rarely widely depressed ovate, 10–12.5(–14.6) mm long, (9–)10–1.5(–14.6) mm wide, the tube (8.4–)10.7–15.7 mm long; stamens 5(–6), the filaments in long styled flowers 16–23 mm long, the upper 5.7–9.5 mm free, in short-styled flowers (16–)19–27 mm long, the upper (9–)10–14.5 free, pubescent at the point of insertion or rarely glabrous, the anthers oblong, 2.8–4.1 mm long; ovary broadly depressed ovoid, 0.9–1.5(–2) mm long, 1–2 mm broad, glabrous; disc transversely ellipsoid to obloid, 0.8–1 mm tall, 0.9–1.8 mm broad, glabrous or sparsely ciliate at the upper edge; style in long-styled flowers 20–30 mm long, in short-styled flowers (9.5–)11–16 mm long, the stylar branches 2–4.6(–6.8) mm long, the stigma

lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid to narrowly ellipsoid, 7–10 mm long, 2–3 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—*Cordia sonorae* occurs in western Mexico in dry forests with a northern population in Chihuahua and Sinaloa, a disjunct population on María Madre Island in Nayarit, and a more southern population in Michoacán and Guerrero. It ranges from sea level to 600(–1,000) m in elevation.

Representative specimens examined: **MEXICO. Chihuahua:** N side of Barranca de Batopilas, between Potrero and junction of Arroyo Samachique with Río Batopilas, elev. 600 m *Bye 3458* (INIF, MEXU). **Guerrero:** 50 km S of Iguala, 11 km S of Río Mexcala, elev. 600 m, *Miller et al. 678* (MO). **Michoacan:** along Mexican Highway 200 between Playa Azul and Tecomán, Colima, 6 km W of Maruhuata, elev. 30 m, *Miller & Tellez 3088* (MEXU, MO). **Nayarit:** María Madre Island, *Nelson 4207* (F, US). **Sinaloa:** between Rosario and Villa Union, *Gentry 12598* (LL, MEXU). **Sonora:** about 5 mi. below Minas Nuevas, *Rose et al. 12668* (NY, US).

Cordia sonorae is not uncommon in northwestern Mexico from Guerrero north to Sinaloa and Chihuahua. It is most easily confused with *C. morelosana* (see remarks under that species).

20. Cordia thaisiana G. Agostini, Brittonia 25:174. 1973. (**Fig. 6**). TYPE: VENEZUELA. ZULIA: between Maracaibo and Villa del Rosario, 15 Mar 1972, *J. Steyermark, G.C. K. & E. Dunsterville 105,527* (HOLOTYPE: VEN; ISOTYPES: GH, NY, US).

Tree to 20 m tall, the twigs glabrous. Leaves deciduous; petioles 5–20 mm long, canaliculate on the adaxial surface, glabrous or nearly so; blades elliptic-obovate, 4–12 cm long, 1.5–4 cm wide, the apex short acuminate to acute, the base narrowly cuneate, the margin entire, the adaxial surface glabrous, sometimes pustulate, the abaxial surface glabrous. Inflorescences terminal, cymose, 3.5–5 cm broad, 12–15-flowered, the branches sparsely strigose. Flowers distylous, borne with the leaves; calyx tubular, 8–9 mm long, ca. 3.5 mm wide at the mouth, glabrous or nearly so, usually 3–4 lobed, the lobes uneven, ovate, 3–3.5 mm long, not evidently ribbed but merely striate; corolla white, 15–24 mm long, (4–)5-lobed, the lobes oblong, parallel-sided, 6–10 mm long, 5–8 mm wide, the tube 9–10 mm long; stamens the same number as the corolla lobes, the filaments 13–15 mm long, the upper 7–8 mm free, pubescent at the point of insertion, the anthers oblong, 4–5 mm long; ovary ovoid, 1–1.2 mm tall, 1 mm broad, glabrous; style 5–6 mm long, the stylar branches almost not evident, the four stigmas arising directly from the tip of the style, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, ellipsoid, ca. 5 mm long, one-seeded, the wall fibrous.

Distribution and habitat.—*Cordia thaisiana* occurs in dry forests in western Venezuela and adjacent Colombia.

Specimens examined: **COLOMBIA. Atlantico:** Trail from Baranca to Campeche, *Dugand 328* (F); in El Paraiso, *Dugand 521* (F); road from Baranca to Campeche, *Dugand 553* (F); Selva en las cercania de Molinero, elev. 50–150 m, *Dugand 573* (US); near Molinero, *Dugand 575* (F). **La Guajira:** along the rail road Corridor from the Cerrejón mine to Bahía Portete, *Arboleda s.n.* (MO); Mpio. Maicao, alongthe railroad corridor from the Cerrejón mine to Bahía Fortette, *Bunch et al. 423* (MO); Carretera Ibania—Puerto Bolívar, Km 15–24, elev. 150 m, *Roldán 1029* (MO, NY). **Santander:** Corregimiento de Puerto Olaya, Bufalera "El Bosque," Reserva "Santa Isabela," El Mango, elev. 220 m, *Fonnegra et al. 8112* (HUA, MO); Corregimiento Puerto Olaya, Bufalera "El Bosque," Reserva "El Ecuador," Bosque Puerto Arturo, alrededor de Ciénaga "El Encanto," elev. 220 m, *Fonnegra 8171* (HUA, MO). **VENEZUELA. Barinas:** Reserva Forestal de Ticoporo, dist. Pedraza, elev. 100–150 m, *Araque & Rodriguez-Carrasquero 16* (MO); Reserva Forestal de Caparo, al Norte de los Ríos Uribante Y Apure y al sur del Caño Anarú, *Marcano-Berti 2860* (MO); *Marcano-Berti 2894* (MO); *Marcano-Berti 2895* (MO). **Falcon:** A lo largo de la carretera entre Dabajuro—La Danta—Bariro, 22–24 km sur de Dabajuro, elev. 160 m, *Bunting & Bowles 5074* (NY). **Lara:** Cerca de Barquisimeto, *Smith V-3672* (VEN). **Zulia:** carretera Maracaibo—Villa del Rosario—Machiques, *Aristeguieta et al. 6791* (NY, VEN); Camino de Playa Bonita, Río Guasare, elev. 70 m, *Medina 969* (VEN); Dist. Mara, along road 2 km S of Campamento Carichuano of Corpozulia, elev. 100 m, *Steyermark et al. 122901* (MO, NY); Dist. Mara, 4 km (by air) N or Corpozulia Campamento Carichuano, elev. 150–200 m, *Steyermark 123057* (MO, NY); Dist. Mara, 1 km W of Corpozulia Campamento Carichuano, elev. 80 m, *Steyermark et al. 123143* (MO); Dist. Mara, near Hacienda La Bagueta, 2 km (by air) NE of Campamento Carichuano, elev. 80 m, *Steyermark et al. 123310* (MO, NY).

Cordia thaisiana is easily recognized by its glabrous leaves, striate (not ribbed) calyx, and corollas lobes that are parallel-sided.

21. Cordia tinifolia Willd. ex Roem. & Schult., Syst. Veg. 4:800. 1819. (**Fig. 7**). *Gerascanthus tinifolius* (Willd. ex Roem. & Schult.) Borhidi, Acta Bot. Hung. 34:398. 1988. TYPE: MEXICO. GUERRERO: Acapulco, *ex herb. Willd.* (HOLOTYPE: B; fragment of type, G).

Tree 5–15 m tall, the twigs glabrous white-lenticellate. Leaves deciduous; petioles (2–)5–12(–20) mm long, flattened on the adaxial surface, glabrous; blades elliptic to narrowly elliptic, 4.2–13(–15) cm long, (1.5–)2–5.5

cm wide, the apex acute, the base acute, the margin entire to slightly undulate, the adaxial surface glabrous, the abaxial surface glabrous. Inflorescences terminal, paniculate, 5–10 cm long, branches short-tomentose to puberulent, the hairs dark brown. Flowers distylous, on pedicels to 5 mm long; calyx tubular, 8.5–11.5 mm long, 2.3 mm wide at the mouth, 4–5-lobed, the lobes variable, short teeth or deltate to 1 mm long, 10-ribbed, short-tomentose to sparsely pubescent, the hairs short, wavy, mostly restricted to grooves between the ribs; corolla white, funnelform, 21–27 mm long, 5-merous, the lobes widely depressed ovate, 3–7 mm long, 7–10 mm wide, the tube 11.5–18 mm long; stamens 5, the filaments 13–22 mm long, the upper 5.5–15 mm free, pubescent just above the point of insertion, the anthers oblong, 2–2.5 mm long; ovary broadly ovoid to broadly oblong, 0.7–1.5 mm long, 0.7–9.5 mm broad, glabrous; disc depressed obovoid, 0.2–0.7 mm tall, 0.7–1 mm broad, ciliate on the upper margin; style 12–13 mm long, the stylar branches 2–6.5 mm long, the stigma lobes clavate. Fruits unknown.

Distribution and habitat.—*Cordia tinifolia* is endemic to Guerrero and is known only from the dry forests in the vicinity of Acapulco.

Specimens examined: **MEXICO. Guerrero:** Acapulco, *Gillis 10318* (A, MO, TEX); without definite locality, *Haenke 1189* (F); hills W of Acapulco, *Howell 8491* (CAS); Coluchuca, elev. 50 m, *Langlasse 732* (G, GH, K, P, US); Costa Vera, Acapulco, *Langman 3328* (MO); Mpio. San Marcos, 54 km al E de Acapulco, carretera Acapulco—Pinotepa Nacional, *Martinez & Tellez 106* (MEXU, MO); Playa Roqueta Acapulco, *Miranda 4085* (MEXU); Acapulco and vicinity, *Palmer 236* (F, K, MEXU, MICH, MO, NY, US); Acapulco, *Paray 1466* (ENCB); Acapulco, *Rusby s.n.* (K).

Cordia tinifolia is an infrequently collected species that occurs in the hills around Acapulco in western Mexico. It is distinct in its paniculate inflorescence, corolla with lobes wider than long, and short calyx only 8.5–11.5 mm long. It apparently flowers while it still has leaves.

22. Cordia trichotoma (Vell.) Arrab. ex Steud., Nomencl. Bot. 419. 1840. (**Fig. 1**). *Cordiada trichotoma* Vell., Fl. Flumin. 98. Tab. 156, T. 2. 1825. *Gerascanthus trichotomus* (Vell.) M. Kuhlm. & Mattos, Loefgrenia 47:1. 1970. TYPE: BRAZIL. DISTRITO FEDERAL: Silvis maritimis Regii Praedii Sanctae Crusis, Figure 156 in Volume 2 of Velloso, Flora Fluminensis Icones (LECTOTYPE, here designated). The specimens from which Velloso described new species were apparently deposited at R with duplicates sent to Lisboa and later transported to Paris, but not material has been located at any of these places. The illustration in Velloso's Icones is adequate to be recognized as the present species.

Cordia asterophora Mart. ex Fresen., Fl. Bras. 8:5. 1857. *Gerascanthus asterophorus* (Mart. ex Fresen.) Borhidi, Acta Bot. Hung. 34:396. 1988. *Lithocardium asterophorum* (Mart. ex Fresen.) Kuntze, Revis. Gen. Pl. 2:976. 1891. TYPE: BRAZIL. BAHIA: catingas, Dec 1818, *Martius s.n.* (HOLOTYPE: M; ISOTYPE: B).

Cordia chamissoniana Steud. (not G. Don, 1837), Nomencl. Bot. (ed. 2) 1:417. 1841. TYPE: BRAZIL: 1839. *Riedl 62* (HOLOTYPE: BR).

Cordia chammissoniana var. *genuina* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:214. 1921.

Cordia chammissoniana var. *aemilii* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:214. 1921. TYPE: PARAGUAY: Sierra de Amambay, *Hassler 11225* (LECTOTYPE, here designated: G; ISOLECTOTYPES: B, G, K). Chodat cited more than one specimen with the original description, and the collection cited here is the most widely distributed.

Cordia chammissoniana var. *blanchetii* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:214. 1921. *Cordia trichotoma* f. *blanchetii* (Chodat) I.M. Johnst., Contr. Gray Herb. 92:17. 1930. *Gerascanthus trichotoma* f. *blanchetii* (Chodat) M. Kuhlm. & Mattos, Loefgrenia 47:1. 1970. TYPE: BRAZIL. BAHIA: Serra Jacobina, *Blanchett 2559* (HOLOTYPE: G; ISOTYPES: B, BM, G, K, NY).

Cordia chammissoniana var. *gardneri* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:214. 1921. TYPE: BRAZIL: Crato, 1838. *Gardiner 1780* (HOLOTYPE: G; ISOTYPES: GH, K, NY, S).

Cordia chammissoniana var. *martii* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:214. 1921. TYPE: BRAZIL: *Martius Herb. Bras. 1067* (LECTOTYPE, here designated: G; ISOLECTOTYPES: B, BM, G, K, NY). This is the most widely distributed of the specified syntypes.

Cordia chammissoniana var. *nemorensis* Chodat, Bull. Soc. Bot. Genève, sér. 2, 12:214. 1921. TYPE: PARAGUAY: Ybytymi, Sep 1874, *Bolansa 2030a* (HOLOTYPE: G; ISOTYPE: K).

Gerascanthus excelsus Mart., Flora 21(2 Beibl. 4):86. 1838. *Lithocardium excelsum* (Mart.) Kuntze, Revis. Gen. Pl. 2:977. 1891. TYPE: BRAZIL: *Martius Herb. Bras. 486* (HOLOTYPE: G; ISOTYPES: B, BM, K, NY). *Cordia excelsa* (Mart.) A. DC., Prodr. 9:473. 1845.

Cordia frondosa Schott., Syst. Veg. 4:403. 1827. TYPE: BRAZIL: *ex Herb. Spreng.* (HOLOTYPE: B).

Cordia hassleriana Chodat, Bull. Herb. Boissier, sér. 2, 2(9):815. 1902. TYPE: PARAGUAY: Cordillera de Altos, *Hassler 3952* (HOLOTYPE: G; ISOTYPES: B, BM, G).

Cordia hypoleuca A. DC., Prodr. 9:472. 1845. *Lithocardium hypoleucum* (A. DC.) Kuntze, Revis. Gen. Pl. 2:977. 1891. *Gerascanthus hypoleucus* (A. DC.) Borhidi, Acta Bot. Hung. 34:397. 1988. TYPE: BRAZIL: circa Rio de Janeiro, 1834, *Lund s.n.* (HOLOTYPE: G; ISOTYPE: B).

Cordia tomentosa Cham. & Schldl., Linnaea 4:472. 1829. *Gerascanthus trichotoma* f. *tomentosus* (Cham. & Schldl.) M. Kuhlm. & Mattos, Loefgrenia 47:2. 1970. TYPE: BRAZIL: *Sellow 1571* (LECTOTYPE, here designated: B). *Cordia trichotoma* f. *tomentosa* (Cham. & Schldl.) I.M. Johnst., Contr. Gray Herb. 92:17. 1930.

Lithocardium gerascanthus var. *puberulum* Kuntze, Revis. Gen. 2:977. 1891. *Cordia trichotoma* f. *puberula* (Kuntze) I.M. Johnst., Contr. Gray Herb. 92:17. 1930. *Gerascanthus trichotoma* f. *puberula* (Kuntze) M. Kuhlm. & Mattos, Loefgrenia 47:1. 1970. TYPE: ARGENTINA. SALTA: Tabacal near Orán, July 1873, *Lorentz & Hieronymus* 527 (HOLOTYPE: NY; ISOTYPES: B, G, S).

Tree 6–25 m tall, the twigs densely stellate-pubescent. Leaves deciduous; petioles 1–4 cm long, canaliculate on the adaxial surface, densely stellate-pubescent; blades ovate to lanceolate, elliptic, or obovate, 6–15 cm long, 3–8 cm wide, the apex acute, the base acute, the margin entire, the adaxial surface glabrous or with sparse stellate hairs, the lower surface densely stellate-pubescent to stellate-tomentose. Inflorescences terminal, cymose-paniculate, 8–30 cm broad, the branches densely stellate-pubescent. Flowers of three distinct morphs, two distylous morphs and one homostylous, non-herkogamous morph; calyx tubular, 6.5–9 mm long, ca. 2.5–3.5 mm wide at the mouth, 10-ribbed, stellate-pubescent, (4–)5-lobed, the lobes acute, ca. 1 mm long, or nearly not evident; corolla white, 12–17(–24) mm long, tubular with spreading lobes, 5–(6)-lobed, the lobes 6–9 mm long, 3–5 mm wide, the apex truncate, the tube 6–8 mm long; stamens the same number as the corolla lobes, the filaments 11–15 mm long, the upper 5–7 mm free, pubescent at the point of insertion, the anthers oblong, 2.5–3 mm long; ovary ovoid to broadly ovoid, 1–1.5 mm tall, ca 1 mm broad, glabrous; style 6–10 mm long, the style branches 2–3 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, subcylindrical, one-seeded, the wall fibrous.

Distribution and habitat.—*Cordia trichotoma* ranges from Pernambuco in northeast Brazil through Bolivia and Paraguay into northern Argentina from sea level to 1,000 m.

Representative specimens examined: **ARGENTINA. Corrientes:** Santo Tomé, Ea. Bertrán (Infrán Cué), 23 km SW de Virasoro, *Tressens, et al. 4021* (CTES). **Jujuy:** Quinta por Laguna de la Brea, *Fries 172* (MO). **Salta:** Ruta 34 a la salido de Tetán rumbo aGralguemes, en la proximidades del empalme con la Ruta 16, *Novare 461* (MO). **Misiones:** Cerro Azul, *Krapovickas et al. 15061* (F). **BOLIVIA. Beni:** Marban, elev. 200 m, *Seidel et al. 6591* (M). **Chuquisaca:** Hernando Siles, Serranía Los Milagros, Pendiente media al Sur de la Laguna, elev. 1,630 m, *Serrano et al. 7052* (HSB, MO, NY). **La Paz:** Bautista Saavedra, elev. 1,600 m, *Zenteno 794* (M). **Santa Cruz:** Nuflo de Chavez, elev. 500 m, *Killeen 975* (F, LPB, M). **Tarija:** Arce, 29.2 km S of Emborozú—Sidras road on road to Bermejo, (12.7 kn S of Naranjo Agrio), elev. 600 m, *Solomon 9969* (MO). **BRAZIL. Alagoas:** Mun. de Quebrangulo, Reserva Biológica de Pedra Ralhada, *Cervi et al. 7192* (MO). **Bahia:** Mpio. of Traquara, Fazenda Pratinha, margin of Río San Antonio, 16 km SSE of Iraquara, elev. 600 m, *Mori et al. 14413* (MO, NY). **Ceara:** Iparana, mata em restinga, *Stehmann 28136* (MO). **Distrito Federal:** Bacia de Río de Sao Bartolomeu, *Heringer et al. 4535* (MO, US). **Espiritu Santo:** Linhares, *J.S. 045/78* (MO). **Goias:** ca. 5 km S of Caiapônia, elev. 850 m, *Anderson 9475* (US). **Maranhao:** Carolina, close to Río Lajes, *Ratter 6767* (MO). **Minas Gerais:** Mpio. of Santa Luzia, in campo, between Venda Nova and Vespasiano, elev. 900–1,000 m, *Williams & Assis 6741* (F, MO, US). **Mato Grosso:** Sidrolandia, *Hatschbach 21783* (MO). **Parana:** Alto Parana, Rod. do Café, *Hatschbach 14424* (F, US). **Pernambuco:** Tapera, *Pickel 3113* (F, US). **Rio De Janeiro:** Rio de Janeiro, *Riedl 572* (MO). **Rio Grande Do Sul:** San Leopoldo, *Rambo 42203* (F). **Sao Paulo:** Mpio. de Matao, 12 km SSE of Matao (ca. 17 kn NW along the S. Jose do Río Preto—Araraquara highway from turnoff to Araraquara), elev. 600 m, *Eiten et al. 3002* (MO, US). **Santa Catarina:** Dourado, Itapiranga, elev. 50 m, *Klein 5234* (US). **PARAGUAY. Alto Parana:** Centre forestier du Haut Parana, 12 km a l'ouest de Ciudad del Este, *Stutz 1394* (G, MO). **Caaguazu:** Ruta 2, Km 98, *Zardini & Aguayo 10582* (FCQ, MO). **Caazapa:** Parque Nacional Caaguazú, *Pérez de Molas 863* (MO). **Canindeyu:** Terreno del Banco Mundial, 34 km E of Villa Ygatimi near Río Jujui-mi, elev. 150 m, *Gentry et al. 59399* (MO). **Central:** Villa Elisa, *Pedersen 3175* (US). **Concepcion:** Arroyo Tagatiyá-Guazú at Estancia Bello Horizonte, elev. 270 m, *Zardini & Guerrero 41198* (AS, MO). **Cordillera:** Altos, camino a Loma Granda, *Basualdo 2603* (MO). **Guaira:** Colonia Independencia, *Hahn 2207* (MO). **Paraguari:** 90 km NE Asuncion, Parque Nacional Ybycul, *Little 40035* (MO). **San Pedro:** Calle Ovetense, 12 km al NE de Choré, *Zardini & Benitez 3416* (MO, PY).

Cordia trichotoma is a common species in Eastern Brazil that ranges south through parts of Bolivia and Paraguay to northern Argentina. It is easily recognized by its stellate pubescence, generally velutinous on the lower leaf surfaces. It is most easily confused with *C. alliodora*, but differs in lacking ant domatia, having leaves that are velutinous below, and larger flowers. It is valued as a timber tree throughout its range.

23. Cordia umbellifera Killip ex Agostini, Acta Bot. Venez. 9:292. 1974. (**Fig. 6**). TYPE: VENEZUELA. GUARICO: near Dos Caminos, in light forest, *Pittier 12531* (HOLOTYPE: VEN; ISOTYPES: F, G, GH, K, M, MO, NY).

Cordia wurdackiana Feuillet, BioLlania (Edición Especial) 6:331. 1997. TYPE: GUYANA: Rupununi District, Kusad Mountains, flroest along creek on slope, 240–450 m, *Jansen-Jacobs et al. 2696* (HOLOTYPE, US; ISOTYPE, MO).

Tree to 8 m tall, the twigs glabrous. Leaves deciduous; petioles 3–9 mm long, canaliculate on the adaxial surface, sparsely villous or glabrous; blades elliptic, 3.5–10 cm long, 0.9–3.7 cm wide, the apex acuminate to acute, the base acute, the margin entire, the adaxial surface glabrous, the abaxial surface glabrous. Inflorescences terminal, condensed, umbellate, 15–20-flowered, to 4 cm broad. Flowers distylous; calyx tubular, 11–13 mm long, 2–2.5 mm wide at the mouth, brown puberulent between the ribs, 5-lobed, but often only separating into

2–3 lobes, the lobes uneven, ovate, 0.5–2 mm long, evidently 10-ribbed; corolla white, funnelform, 18–21 mm long, (4–)5-lobed, the lobes 5.5–6 mm long, 4.5–4.7 mm wide, the apex acute, the tube 5–6 mm long; stamens 4–5, the filaments 12–17 mm long, the upper 7–9 mm free, pubescent at the point of insertion, the anthers oblong, ca. 2 mm long; ovary depressed ovoid, ca. 1 mm tall, 0.6–0.8 mm broad, the style 8–11 mm long, the stylar branches 2–4 mm long, the stigma lobes clavate. Fruits enclosed by the persistent calyx and corolla, brown, narrowly ellipsoid, 5.5–6 mm long, ca. 2.5 mm broad, one-seeded, the wall fibrous.

Distribution and habitat.—Cordia umbellifera occurs in Eastern Venezuela and adjacent Guyana from sea level to 450 m.

Specimens examined: **VENEZUELA. Bolivar:** Proc. Criollo, Ciudad Bolívar, entre el "Club Nautico Y Angosturita," elev. 20 m, *Diaz 6318* (MO); northern most slopes of Cerro Baraguan, 100–330 m, *Wurdack & Monachino 41238* (MO, NY). **Guarico:** Entre Camatagua y El Sombrero, *Aristeguieta 5985* (NY, VEN); *7289* (VEN); between Ortiz & Guárico Bridge, *Pittier 12222* (NY); Ortiz-Galeras de El Pao, 20 km de San Francisco de Tiznado, *Aristeguieta et al. 6269* (VEN); Paso Real, road to Cementerio, *Plowman 1910* (US).

Cordia umbellifera is an uncommonly collected species that can be recognized by its corollas with lobes wider than long, pubescent staminal filaments, and highly condensed, umbellate inflorescences.

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JOURNAL REVIEW

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The second section looks at the patterns, drivers, and consequences of human uses of natural resources and interactions with the environment. This section contains several reviews related to energy (e.g., policy and technology for managing the impacts of coal energy productions; the link between water used to produce energy and energy used to treat and transport water), and other papers examine mechanisms to combat and remediate land degradation and the development of green chemistry and its applications. These papers contribute to our understanding of energy, water, agriculture, and human behavior and identify important future research agendas.

The third section explores environmental governance and policy. These papers look at policy efforts to end deforestation, the relationship of tourism, religion, and literature to the environment, and the links between human development, disasters, well-being, and resilience.

The papers that make up this review volume contend with the challenges and conflicts inherent in meeting people's needs while protecting natural resources and the environment. The volume aims to foster communication among various disciplines active in research, as well as informing managers, policy makers, and the public who rely on such information to assist decision making. I would recommend this volume to students and professionals who work in integrated resource management.—*Kevin Janni, Botanist, SWCA Environmental Consultants, and Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

NOVELTIES IN *SERPOCAULON* (POLYPODIACEAE)

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ABSTRACT

We present five nomenclatural novelties in *Serpocaulon:* **S. articulatum** (C. Presl) Schwartsb. & A.R. Sm., the correct name for the specimens long called as *S. giganteum* (or *Polypodium giganteum*); **S. rex** Schwartsb. & A.R. Sm., a new species from the Seasonal semi-Deciduous Forest of southeastern Brazil; **S. hirsutulum** (T. Moore) Schwartsb. & A.R. Sm., a species commonly regarded as doubtful; **S. ×pubescens** (Rosenst.) Schwartsb. & A.R. Sm., a putative hybrid between *S. menisciifolium* and *S. hirsutulum*; and **S. laetum** (C. Presl) Schwartsb. & A.R. Sm., the correct name for the species recently renamed *S. sehnemii*. In addition, we provide a new conspectus of the genus in Brazil, with a key to the species with fully pinnate laminae.

RESUMO

São apresentadas cinco novidades nomenclaturais em *Serpocaulon:* **S. articulatum** (C. Presl) Schwartsb. & A.R. Sm., o nome correto para os espécimes tradicionalmente chamados *S. giganteum* (ou *Polypodium giganteum*); **S. rex** Schwartsb. & A.R. Sm., uma espécie nova da Floresta Estacional semi-Decídua do sudeste do Brasil; **S. hirsutulum** (T. Moore) Schwartsb. & A.R. Sm., uma espécie comumente tratada como "duvidosa"; **S. ×pubescens** (Rosenst.) Schwartsb. & A.R. Sm., um suposto híbrido entre *S. menisciifolium* e *S. hirsutulum*; e **S. laetum** (C. Presl) Schwartsb. & A.R. Sm., o nome correto para a espécie recentemente renomeada *S. sehnemii*. Em adição, é apresentado um novo conspecto do gênero para o Brasil, juntamente com uma chave para as espécies com a lâmina 1-pinada.

INTRODUCTION

Serpocaulon A.R. Sm. (Polypodiaceae) is a Neotropical genus comprising ca. 40–45 species with goniophlebioid venation (= areoles with one free included veinlet; veins free only in *S. patentissimum* (Mett. ex Kuhn) A.R. Sm., from Colombia, Ecuador; and *S. funckii* (Mett.) A.R. Sm., from Colombia and Venezuela to Bolivia) (Smith et al. 2006; Labiak & Prado 2008). The genus was recently segregated from *Polypodium* L. and *Goniophlebium* (Blume) C. Presl, and had been called the "*Polypodium loriceum* L. complex" (Hensen 1990; Moran 1995). In the Brazilian Atlantic Forest, 10 species are known to occur (Labiak & Prado 2008), although ca. 35 basionyms are referable to them (e.g., Raddi 1825; Fée 1869, 1873; Baker 1870; Hensen 1990).

During a field expedition taken in the Seasonal semi-Deciduous Forest of southeastern Brazil, an understudied sub-formation of the Atlantic Forest, a new species of *Serpocaulon* was found. While comparing it to *S. giganteum* (Desv.) A.R. Sm., we noticed this name needs re-interpretation, and we provide a new combination.

In addition, we propose three new nomenclatural novelties in *Serpocaulon* from the Brazilian Atlantic Forest: the recognition of a species usually regarded as doubtful, the recognition of a putative hybrid, and the correct name for the species recently renamed *S. sehnemii* (Pic. Serm.) Labiak & J. Prado. We also provide a new conspectus of the genus diversity in Brazil, with a key to the species with fully pinnate laminae.

The materials analyzed are marked with an exclamation mark ("!"); an "*" means we saw their images either online (at JStor Plant Science and Swedish Museum of Natural History websites), or sent by herbarium staff (see acknowledgments).

NOMENCLATURAL NOVELTIES

1. Serpocaulon articulatum (C. Presl) Schwartsb. & A.R. Sm., comb. nov. BASIONYM: *Goniophlebium articulatum* C. Presl, Tent. Pterid. 186. 1836, *nom. nov.* for *Polypodium articulatum* Desv., Mém. Soc. Linn. Paris 6:236. 1827, *nom. illeg.* (non Juss. ex Poir. 1804, nec Vahl 1807). *Polypodium fraxinifolium* Jacq. subsp. *articulatum* (C. Presl) Christ, Bull. Herb. Boissier, sér. 2, 6:49. 1906, as "(Desv.) Christ." TYPE: *Anonymous, ex Herb. Desvaux* (LECTOTYPE, redesignated here: P*-00624694).

Polypodium fraxinifolium Jacq. subsp. *luridum* Christ, Bull. Herb. Boissier, sér. 2, 6:48. 1906. TYPE: COSTA RICA: Navarro, 1400 m, 1901–1905, *C. Wercklé s.n.* (BR?-n.v., NY*-frag., P?-n.v., US*-00065826).

This species has commonly been called *Polypodium giganteum* Desv. (Lellinger 1985, 1989; Moran 1995), or *Serpocaulon giganteum* (Desv.) A.R. Sm. (Smith et al. 2006). However, the type of *P. giganteum* (*Anonymous, ex Herb. Desvaux* [P*-00637550]) corresponds to a species of *Niphidium* J. Sm. (Polypodiaceae), probably *N. crassifolium* (L.) Lellinger, widespread in the Neotropics. We here provide a better name (along with its new combination) for the specimens long named "*Serpocaulon giganteum*" or "*Polypodium giganteum*": *Serpocaulon articulatum*.

The characterization of this species can be found in Lellinger (1989) and Moran (1995), as "*Polypodium giganteum*." Although Smith et al. (2006) cited this species (as *Serpocaulon giganteum*) from southern Brazil, in Brazil it probably occurs only in the northern region, in the Amazon Forest (see Labiak & Prado 2008; Labiak & Hirai 2010).

Lellinger (1985) correctly attributed the combination *Polypodium fraxinifolium* subsp. *articulatum* to Christ (1906), and not a new combination based on Desvaux's illegitimate name. However, he mistakenly designated as lectotype a specimen cited by Christ: *Pittier 9061* (US*-00065825). There is one sheet at P (P*-00624694) that corresponds to Desvaux's original material, and it is appropriate to consider that as the lectotype (ICBN Art. 9.17), redesignated here.

2. Serpocaulon rex Schwartsb. & A.R. Sm., sp. nov. (**Figs. 1A–H**). TYPE: BRAZIL. MINAS GERAIS: Frutal, Reserva Floresta Escola, Floresta Estacional Semi-Decídua, próxima ao Rio Grande, 20°13'58"S, 48°53'03"W, 460 m, 10 Aug 2012, *P.B. Schwartsburd 2596 & L.M. Alves* (HOLOTYPE: SP!; ISOTYPES: K!, P!, UC!, VIC!).

Differs from all other species of *Serpocaulon* by the larger size of the erect fronds (1.65–1.8 m long). Differs from other southern/southeastern Brazilian species by the sori in 4–6 rows between the costae and the lamina margins (vs. 1–3(–4) rows).

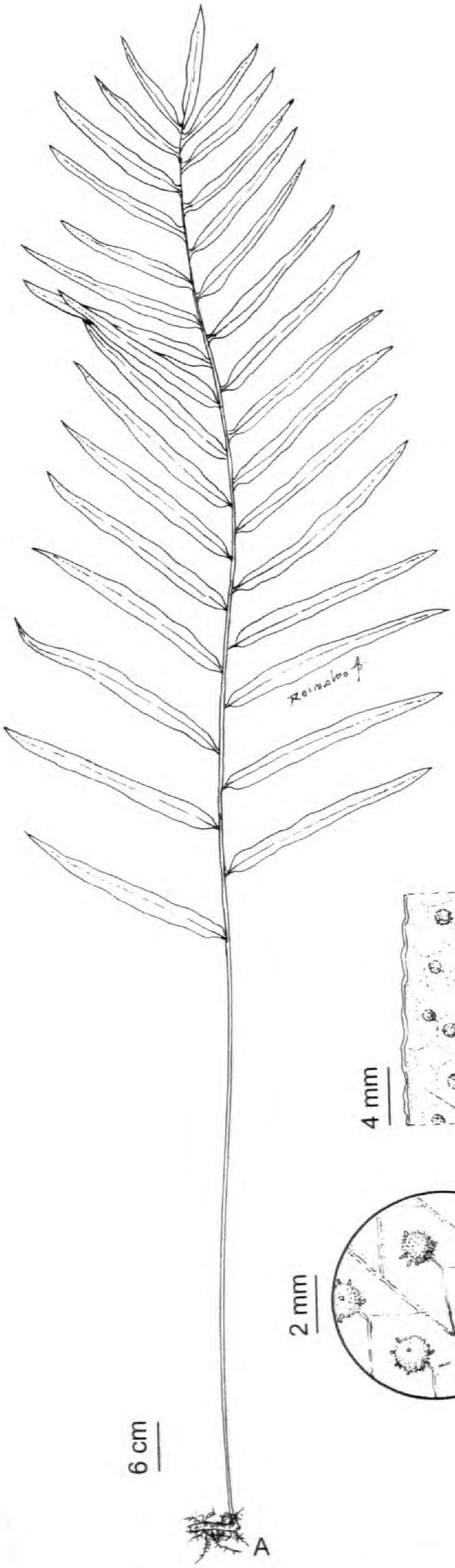
Plants terrestrial. *Rhizomes* long-creeping, stramineous, copiously scaly, 5–10 mm diam.; *scales* lanceolate-acuminate, 0.5–0.75 × 0.2–0.3 mm, peltate basally, clathrate, with margins entire, concolorous. *Fronds* erect, monomorphic, 1.65–1.8 m long; *petioles* brown, glabrous, with two lateral lines of aerophores, 68–77 cm long, 4–6 mm diam.; *laminae* 1-pinnate, linear-acuminate, slightly broader at base, the apex conform, 100–110 × 50–72 cm, lateral pinnae 12–15 pairs; *rachises* glabrous; *proximal and medial pinnae* ascending (sometimes strongly ascending), ca. 45–60° from rachis, linear, often falcate, 25–36 × 2.5–3 cm, with pinna bases inequilateral, cuneate, basiscopically petiolulate, acroscopically sessile, the *margins* cartilaginous, crenate; *costae* nearly glabrous, but abaxially and adaxially with scattered filiform scales 0.4–0.6 mm long and scattered trichomidia 0.1–0.15 mm long, 1–2-celled; *veins* anastomosing in a goniophlebioid pattern, with 5–7 areoles between the costae and the pinna margins, nearly glabrous, but abaxially and adaxially with scattered trichomidia similar to those of the costae; *laminar tissue between the veins* abaxially and adaxially glabrous; *sori* in 4–6 uniseriate rows between main lateral veins running from costae to pinnae margins.

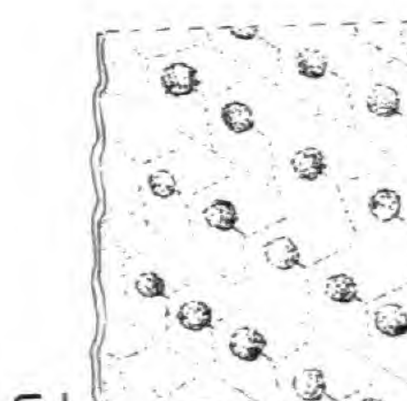
Distribution and ecology.—In the western region of the Brazilian States of Minas Gerais and São Paulo, between the rivers Rio Grande and Tietê. It occurs terrestrially along the margins of streams of Seasonal semi-Deciduous forest. It probably occurs also in the States of Mato Grosso do Sul and Goiás.

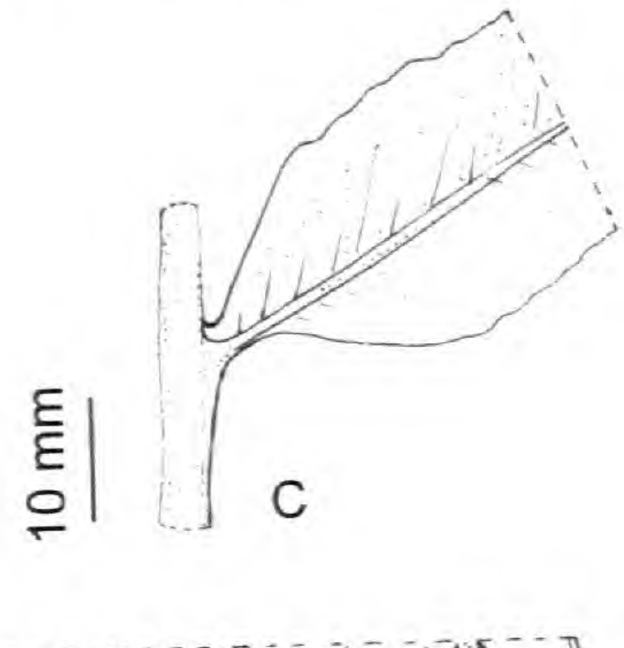
Etymology.—The specific epithet is an allusion to the size of the fronds, which are among the largest in *Serpocaulon*.

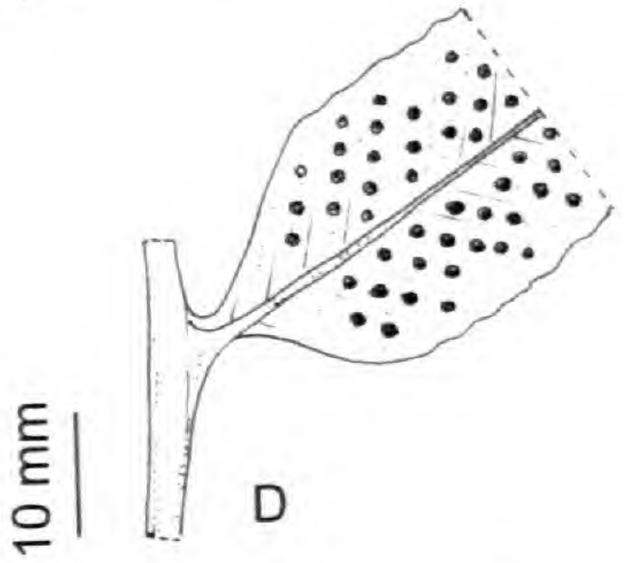
PARATYPES: **BRAZIL. São Paulo:** Borborema, ca. 21°35'S, 49°07'W, 21 Dec 1996, *M.R. Pietrobom-Silva 3917* (SJRP); Cosmorama, 02 Dec 1994, *A.L. Barbosa & W. Forster 21* (SJRP); Nhandeara, ca. 20°43'S, 50°03'W, 18 Jun 1994, *F.R. Nonato & M.R. Pietrobom-Silva 24* (SJRP); Planalto, ca. 21°02'S, 49°55'W, 15 Aug 1996, *M.R. Pietrobom-Silva & F.M. Pedro 3423* (SJRP); Presidente Epitácio, 22°05'S, 52°07'W, 250–300 m, 23 Sep 1996, *M.R. Pietrobom-Silva & C.T. de Lucca 3476* (SJRP); Rosana, região do Pontal do Paranapanema, 22°33'S, 52°44'W, 26 Jul 1997, *M.R. Pietrobom-Silva 4086* (SJRP); Tanabi, 12 Dec 1990, *L.M.S. Viana et al. 1* (SJRP); Teodoro Sampaio, Rio Paranapanema, 22°38'S, 52°45'W, 24–26 Feb 1986, *P.G. Windisch 4720* (SJRP).

Among the pinnate species of *Serpocaulon* from southern/southeastern Brazil, *S. rex* differs from *S. triseriale* (Sw.) A.R. Sm. by stramineous *rhizomes* (vs. dark brown), concolorous *rhizome scales* with the margins entire and clathrate (vs. scales bicolorous with margins subentire and hyaline), *fronds* 1.65–1.8 m long (vs. 0.5–1.2 m











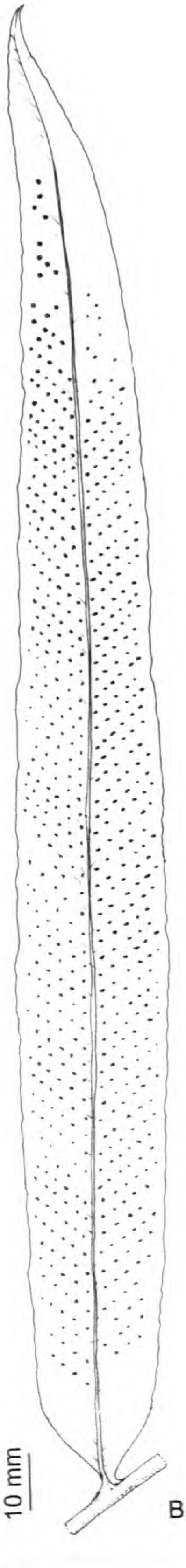


FIG. 1. *Serpocaulon rex* (*Schwartsburd 2596*): **A.** habit; **B.** medial pinna; **C.** base of proximal pinna; **D.** base of medial pinna; **E.** base of distal pinna; **F., G.** details of a medial pinna, abaxially; **H.** rhizome scale.

long), *laminae* with 12–15 pairs of pinnae (vs. 5–10 pairs), *proximal and medial pinnae* with bases basiscopically petiolulate, acrocopically sessile (vs. bases basiscopically sessile, acroscopically adnate), and with crenate margins (vs. margins entire to slightly undulate), and 4–6 rows of *sori* between costae and pinna margins (vs. 1–3 rows)—Figs. 1A–H.

Serpocaulon rex differs from *S. menisciifolium* (Langsd. & Fisch.) A.R. Sm. and *S. hirsutulum* (T. Moore) Schwartsb. & A.R. Sm. by growing terrestrially (vs. epiphytically), *fronds* erect (vs. arched) and much larger, reaching 1.65–1.8 m long (vs. 0.5–1.4 and 0.45–0.55 m long, respectively), *proximal and medial pinnae* with bases basiscopically petiolulate, acrocopically sessile (vs. bases basiscopically sessile, acroscopically adnate), glabrous *rachises* (vs. *rachises* pilose or villous, with septate hairs and lanceolate scales), and 4–6 rows of *sori* between costae and pinna margins (vs. 1–3 rows)—Figs. 1A–H (confront with Figs. 2A–H of *S. hirsutulum*).

Serpocaulon rex differs from *S. fraxinifolium* (Jacq.) A.R. Sm. by growing terrestrially (vs. epiphytically), *rhizomes* thick, stramineous, and copiously scaly (vs. slender, black, and glabrescent or with scattered, non-overlapping, round scales), *fronds* much larger, reaching 1.65–1.8 m long (vs. 0.4–0.9 m long) and erect (vs. arched), *proximal and medial pinnae* with bases basiscopically petiolulate, acroscopically sessile (vs. bases basiscopically and acroscopically sessile), and 4–6 rows of *sori* between costae and pinna margins (vs. 1–3(–4) rows)—Figs. 1 A–H.

To verify that *Serpocaulon rex* had not been already described, we observed online the types of the synonyms of *Polypodium fraxinifolium* Jacq., *P. menisciifolium* Langsd. & Fisch., and *P. triseriale* Sw. listed by Hensen (1990) and ascribed to Brazil: *Goniophlebium excelsior* Fée (*Glaziou 3334* [P*-6 sheets]; = *S. mensiciifolium*), *G. gauthieri* Fée (*Gauthier s.n.* [RB*-31818], *Glaziou 2406* [P*]; = *S. menisciifolium*), *P. albopunctatum* Raddi (illustrations in Raddi 1825!; and in Pichi Sermolli & Bizzarri 2005!; = *S. menisciifolium*), *P. distans* Raddi (illustration in Raddi 1825!; = *S. fraxinifolium*), *P. elatius* Schrad. (*Wied-Neuwied s.n.* [BR*-697061]; = *S. menisciifolium*), *P. lucens* Schrad. (*Wied-Neuwied s.n.* [BR*-697025]; = *S. triseriale*), *P. mosenii* C. Chr. (*Glaziou 4422* [P*-3 sheets], *Mosén 2208* [P*]; = *S. menisciifolium*), and *P. preslianum* Spreng. (type?: *Brackenridge s.n.* [PH*-00021063]; = *S. triseriale*).

Besides the geographical distribution, *Serpocaulon rex* differs from *S. articulatum* by *laminae* with 12–15 pairs of pinnae (vs. 2–7 pairs), and *proximal and medial pinnae* linear-falcate, 2.5–3 cm wide (vs. elliptic, (3–)4–6 cm wide)—Figs. 1A, B.

3. Serpocaulon hirsutulum (T. Moore) Schwartsb. & A.R. Sm., comb. nov. (**Figs. 2A–H**). BASIONYM: *Goniophlebium hirsutulum* T. Moore, Index Fil. (T. Moore) 390. 1862, *nom. nov.* for *Polypodium hirsutulum* Raddi, Pl. Bras. Nov. Gen. 21, t. 29, fig. 2. 1825, *nom. illeg.* (non G. Forst. 1786). TYPE: [BRAZIL]: super palmarum annosarum truncos in viciniis urbis Rio-Janeiro, [Nov 1817–May 1818], *G. Raddi s.n.* (HOLOTYPE: PI*).

Plants epiphytic. *Rhizomes* creeping, chalky-white, copiously scaly, 5–6 mm diam.; *scales* deltate, 1.5–3 × 1.5–2 mm, or deltate and long-acuminate (in plantlets), 4–5 × 1–1.2 mm, peltate basally, clathrate, bicolorous, with margins hyaline, crenate to slightly erose. *Fronds* arched, monomorphic, 45–55 cm long; *petioles* stramineous to light brown, glabrate, without aerophores, 15–20 cm long, 1.8–2.8 mm diam.; *laminae* 1-pinnate, linear-ovate, the apex conform, the distalmost pair of pinnae much reduced, 30–35 × 18–20 cm, lateral pinnae 9–13 pairs; *rachises* abaxially and adaxially densely villous, the *hairs* whitish, lax, 0.5–1.2 mm long, 5–12-celled, abaxially also with sparse scales, the *scales* clathrate, lanceolate, 0.7–1 × 0.5–1 mm; *proximal pinnae* deflexed, *medial pinnae* patent to slightly ascending, ca. 70–90° from rachis, linear-oblong with the *apices* round to obtuse, 9–10 × 1.5–2.2 cm, with pinna bases inequilateral, basiscopically sessile, acroscopically adnate, the *margins* cartilaginous, undulate, villous; *costae* abaxially and adaxially villous, abaxially sparsely scaly; *veins* anastomosing in a goniophlebioid pattern, with 3(–4) areoles between the costae and the pinna margins, abaxially and adaxially villous; *laminar tissue between the veins* abaxially and adaxially villous; *sori* in 1 uniseriate row between main lateral veins running from costae to pinnae margins.

Distribution and ecology.—Epiphytically on the Coastal to Montane Forests of the Brazilian Atlantic Forest, in the States of Rio de Janeiro, Minas Gerais, and São Paulo. Probably, it also occurs in the States of Espírito Santo and Paraná.

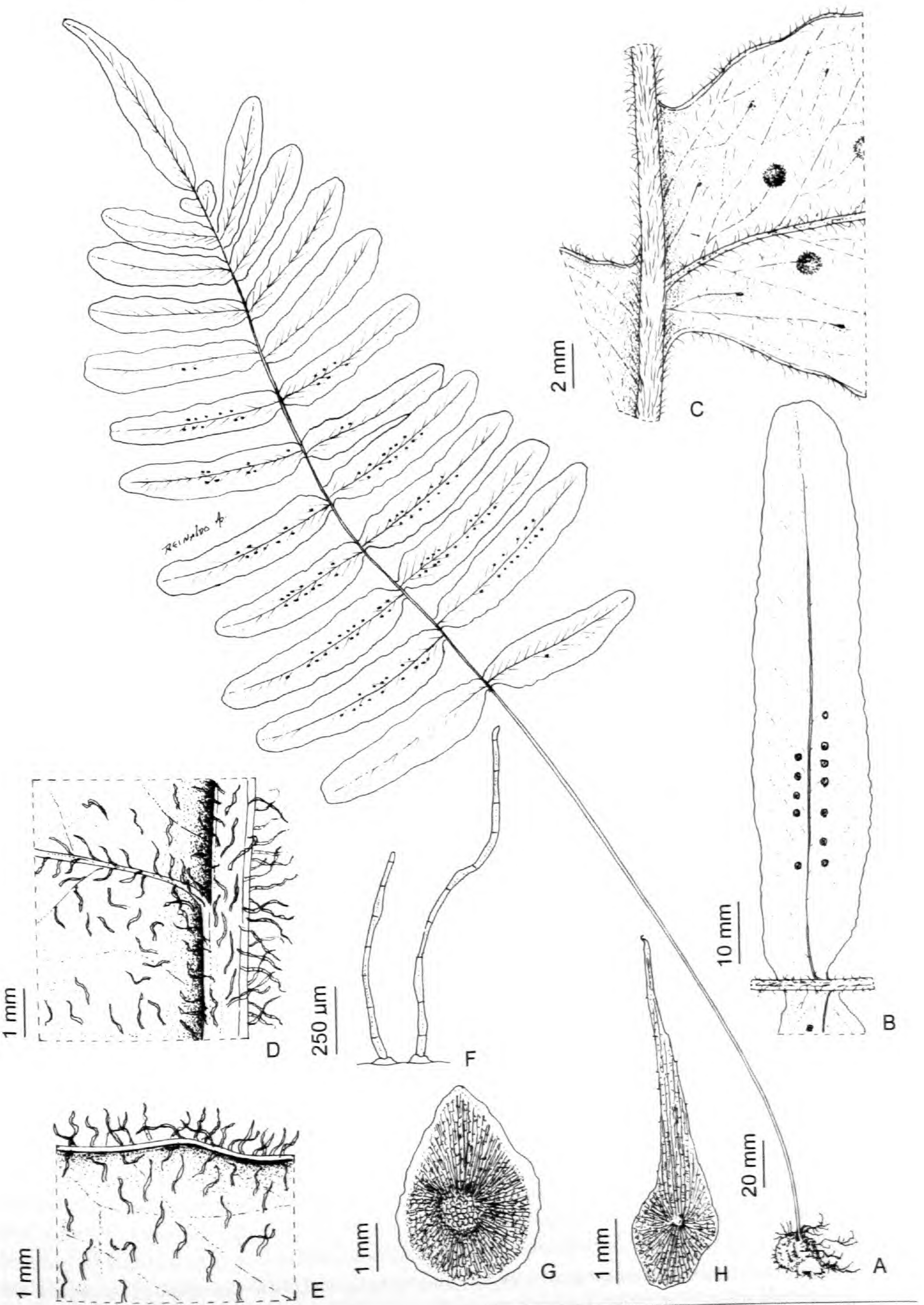


FIG. 2. *Serpocaulon hirsutulum*: **A.** habit; **B.** medial pinna; **C.** base of medial pinna; **D., E.** details of a medial pinna, abaxially; **F.** hairs of rachis; **G.** rhizome scale from adult plant; **H.** rhizome scale from plantlet. A–C, G, H (*Brade 8246*); D–F (*Schwartsburd 2649*).

Additional specimens: **BRAZIL. Minas Gerais:** Tiradentes, Centro Histórico, 16 Nov 2012, *P.B. Schwartsburd et al. 2641* (VIC!); id., Serra de São José, 18 Nov 2012, *P.B. Schwartsburd et al. 2649* (UC!, VIC!). **São Paulo:** Mun. Iguape, Morro das Pedras, May 1922, *A.C. Brade 8246* (HB!, UC!); id., s.d., *A.C. Brade 59976* (HB!).

This species has commonly been regarded as doubtful. After Raddi's (1825) description, Fée (1869, 1873) regarded it as "not well known"; Brade (1951) considered it, with doubts, as a juvenile form of *Polypodium menisciifolium*; and Hensen (1990) synonymized it under *P. menisciifolium*. Pichi Sermolli and Bizzarri (2005) found a solely sterile type-specimen, and also regarded it as synonym of *Goniophlebium menisciifolium* (Langsd. & Fisch.) J. Sm.

On the other hand, Moore (1862) recognized it a species, and included it in the genus *Goniophlebium*. Rosenstock (1925) also recognized it as a species, citing one collection we have examined (*Brade 8246*), and compared it to his *Polypodium menisciifolium* var. *pubescens* Rosenst. On *Brade 8246* (UC), he wrote "*Polypodium raddianum, nom. nov., P. hirsutulum* Raddi," but this name was never published.

There is also an enigma regarding the proper type collection of this species at PI, the only material found by Pichi-Sermolli and Bizzarri (2005) and consisting of a sterile frond, lacking the rhizome. Without doubt, it was the plant illustrated in Raddi (1825: t. 29, fig. 2!). However, in the description of the species, Raddi (1825: 21) indicated "*soris sparsis*." Thus, it is possible that further type material will be found in other herbaria. *Serpocaulon hirsutulum* appears to hybridize with *S. menisciifolium* (see below), thus blurring the interpretation of these taxa.

Serpocaulon hirsutulum differs from *S. menisciifolium* s. str. by smaller *fronds*, 45–55 cm long (vs. 50–140 cm), *laminae* with 9–13 pairs of lateral pinnae (vs. (20–)25–35 pairs), *pinnae* linear-oblong with apices round to obtuse (vs. *pinnae* falcate, apices cuneate to acute) (Figs. 2A, B). In addition, *S. hirsutulum* has the laminae markedly villous, with whitish lax 5–12-celled *hairs*, 0.5–1.2 mm long, on both sides of rachises, costae, veins, laminar tissue between the veins, and laminar margins (Figs. 2C–F). On the other hand, *S. menisciifolium* has stiff hyaline *hairs* with cross-walls reddish, 0.2–0.4 mm long, 3–5-celled, mainly restricted to rachises (especially adaxially), and scattered on costae; the other laminar regions of *S. menisciifolium* are totally glabrous.

The putative hybrids exhibit intermediate morphology, and since they have been formally described, we combine the epithet in *Serpocaulon*.

4. Serpocaulon ×pubescens (Rosenst.) Schwartsb. & A.R. Sm., comb. et stat. nov. BASIONYM: *Polypodium menisciifolium* Langsd. & Fisch. var. *pubescens* Rosenst., Repert. Spec. Nov. Regni Veg. 21:348. 1925. TYPE: BRAZIL. SÃO PAULO: Morro Jaraguá, 08 Dec 1912, *A.C. Brade 5384* (LECTOTYPE, designated here: HB!-39800).

Distribution and ecology.—Epiphytically on the Coastal to Montane Forests of the Brazilian Atlantic Forest, in the States of Rio de Janeiro, Minas Gerais, and São Paulo. Probably, it also occurs in the States of Espírito Santo and Paraná. Rosenstock (1925) listed it also to Rio Grande do Sul.

Additional specimens: **BRAZIL. Rio de Janeiro:** Região de Nova Friburgo, ca. 22°10'S, 42°40'W, 1070 m, 10 Feb 1987, *P.G. Windisch et al. 4978* (HB!). **Minas Gerais:** Tiradentes, Serra de São José, 18 Nov 2012, *P.B. Schwartsburd et al. 2650* (UC!, VIC!). **São Paulo:** Pilar [Pilar do Sul?], 04 Mar 1902, *Gerdes 50* (S*-059227).

Serpocaulon ×pubescens is a putative hybrid between *S. menisciifolium* and *S. hirsutulum*, possibly occurring everywhere both species are present. Although many sporangia and spores are malformed, there are indeed some well-formed ones. Whether or not this putative hybrid can reproduce on its own is unknown.

Serpocaulon ×pubescens presents an intermediate morphology between the two parents: it has the *laminar architecture* (especially the ascending, falcate pinnae, with cuneate to acute apices) of *S. menisciifolium*; an intermediate *number of pinnae* (9–20(–25) pairs); *indument* similar to *S. hirsutulum* on rachises and costae, but with hairs much shorter and sparse on other laminar regions (*hairs* 0.2–0.4 mm long, 2–4-celled, sparse on both sides of costae and veins, scattered on both sides of the laminar tissue between the veins and laminar margins). Common features among these three taxa are: the attachment of *proximal and medial pinnae* (basicopically sessile, acroscopically adnate), lanceolate *scales* present on costae abaxially, and *calcareous dots* on the hydathodes adaxially, an unusual character in the genus.

5. Serpocaulon laetum (C. Presl) Schwartsb. & A.R. Sm., comb. nov. BASIONYM: *Marginaria laeta* C. Presl, Tent. Pterid. 188. 1836, *nom. nov.* for *Polypodium laetum* Raddi, Opusc. Sci. Bol. 3:287. 1819, *nom. illeg.* (non Salisb. 1796). *Goniophlebium laetum* (C. Presl) J. Sm. in Seemann, Bot. Voy. Herald 6:231. 1854 [1855?], as "(Raddi) J. Sm." *Polypodium loriceum* L. var. *laetum* (C. Presl) Baker in Martius & Eichler, Fl. Bras. (Martius) 1(2):523. 1870. *Goniophlebium sehnemii* Pic. Serm., in Pichi Sermolli & Bizzarri, Webbia 60(1):108. 2005, *nom. superfl. Serpocaulon sehnemii* (Pic. Serm.) Labiak & J. Prado, Amer. Fern J. 98(3):153. 2008. TYPE: BRASILIA: [in nemoribus aliquantum udis altorum montium estrellensium], [Nov 1817–May 1818], *G. Raddi s.n.* (LECTOTYPE, designated by Pichi Sermolli & Bizzarri 2005: 108: PI* [spec. 2]; ISOLECTOTYPES: BR*-697793; P*-00633216, P*-00637554; PI-n.v. [spec. 1]).

We consider Presl's (1836) *Marginaria laeta* to be a *nomen novum* for the illegitimate *Polypodium laetum* Raddi and, therefore, the earliest basionym available in *Serpocaulon* for this species (ICBN Art. 58.1, Ex. 1). Characterization of this species can be found in Sehnem (1970), Pichi Sermolli and Bizzarri (2005), Labiak and Prado (2008), and Prado et al. (2010), respectively, as *Polypodium laetum*, *Goniophlebium sehnemii*, *Serpocaulon sehnemii*, and *S. sehnemii*.

THE DIVERSITY OF *SERPOCAULON* IN BRAZIL

Adding the above novelties to recent information (Hensen 1990; Smith et al. 2006; Labiak & Prado 2008; Assis & Labiak 2009; Labiak & Hirai 2010), the Brazilian Atlantic Forest (southern/southeastern Brazil, plus southern Bahia) contains 12 known species of *Serpocaulon*, plus a putative hybrid between two of them. This is ca. 25% of the diversity in the genus. Two species are widespread throughout the Neotropics (*S. fraxinifolium* and *S. triseriale*), one has a disjunct distribution in southeastern/northeastern Brazil, Costa Rica, Panama, Andes, Guadeloupe, Venezuela, and the Guianas (*S. levigatum* (Cav.) A.R. Sm.), two occur in the Atlantic Forest and south-westward to central Brazil, Paraguay, Uruguay, and northern Argentina (*S. catharinae* (Langsd. & Fisch.) A.R. Sm. and *S. vacillans* (Link) A.R. Sm.), four and the hybrid are endemic to the Atlantic Forest s.l. (*S. hirsutulum*, *S. laetum*, *S. latipes* (Raddi) A.R. Sm., *S. menisciifolium*, and *S.* ×*pubescens*), and three are narrow endemics to sub-formations of the Atlantic Forest (*S. glandulosissimum* (Brade) Labiak & J. Prado and *S. mexiae* (Copel.) A.R. Sm. from the highland elfin forests; and *S. rex* from the Seasonal semi-Deciduous Forest). Due to the percentage of the species richness (ca. 25%) and the number of endemics (7 spp. and a hybrid), we affirm the Brazilian Atlantic Forest is a main center of diversity in *Serpocaulon*.

In the Brazilian Amazon (central to northern Brazil) another five or six species occur: *Serpocaulon articulatum*, *S. caceresii* (Sodiro) A.R. Sm. (also in the state of Ceará), *S. panorense* (C. Chr.) A.R. Sm., *S. richardii* (Klotzsch) A.R. Sm., *S. sessilifolium* (Desv.) A.R. Sm., and very probably *S. attenuatum* (Willd.) A.R. Sm. *Serpocaulon fraxinifolium* and *S. triseriale* also occur there (fide Smith et al. 2006; Zuquim et al. 2008; Labiak & Hirai 2010; Carvalho et al. 2012). Brazilian plants ascribed to *S. adnatum* (Klotzsch) A.R. Sm. are better referred to *S. richardii*; *S. adnatum* occurs in western Venezuela, Colombia, and Ecuador.

In total, 17 or 18 species and a hybrid of *Serpocaulon* are known from Brazil, and this is more than a third of the total in the genus. Because of taxonomic uncertainties in the genus and the lack of exploration in certain areas in Brazil, it is likely that there are additional undescribed taxa. A new monographic revision is required to reveal whether some basionyms currently judged as synonyms should be reconsidered as species, especially within the *S. catharinae-latipes* complex.

KEY TO THE BRAZILIAN SPECIES OF *SERPOCAULON* WITH FULLY PINNATE LAMINAE (WITH DISTRIBUTION DATA WITHIN BRAZIL)

1. Medial pinnae acroscopically (at least) adnate to the rachis (e.g., Fig. 2C). ____ **S. triseriale**
   2. Rachises glabrous; hydathodes adaxially without secretions; widespread
   2. Rachises pilose to villous, especially adaxially, with septate hairs and lanceolate scales; hydathodes adaxially commonly with calcareous secretions.
      3. Lateral pinnae (20–)25–35 pairs; veins, laminar tissue between the veins, and laminar margins totally glabrous; Atlantic Forest ____ **S. menisciifolium**
      3. Lateral pinnae 9–20(–25) pairs; veins, laminar tissue between the veins, and laminar margins with septate hairs.
         4. Pinnae apices round to obtuse; veins, laminar tissue between the veins, and laminar margins copiously villous, the hairs 0.5–1.2 mm long, 5–12-celled; Atlantic Forest ____ **S. hirsutulum**
         4. Pinnae apices cuneate to acute; veins, laminar tissue between the veins, and laminar margins sparsely pilose, the hairs 0.2–0.4 mm long, 2–4-celled; Atlantic Forest ____ **S. xpubescens**

1. Medial pinnae acroscopically sessile (e.g., Fig. 1D).
   5. Costae abaxially pilose, with whitish, septate hairs; Amazon basin _____ **S. richardii**
   5. Costae abaxially nearly glabrous, but with scattered trichomidia, linear scales, and/or ovate scales.
      6. Fronds 1.65–1.8 m long; medial pinnae inequilateral, basiscopically petiolulate, acroscopically sessile; plants terrestrial; Atlantic Forest (Seasonal semi-Deciduous Forest) _____ **S. rex**
      6. Fronds 0.4–1.2 m long; medial pinnae basiscopically sessile, ± equilateral at bases; plants usually epiphytic, occasionally terrestrial.
         7. Rhizome scales spreading, dense, strongly clathrate, irridescent; plants terrestrial or epiphytic; Amazon basin and Ceará _____ **S. caceresii**
         7. Rhizome scales appressed, sparse, or barely covering the rhizomes, moderately to weakly clathrate, appearing blackish, not irridescent; plants epiphytic.
            8. Sori in 4–8(–10) rows on each side of costae; pinnae (3–)4–6 cm wide; Amazon basin _____ **S. articulatum**
            8. Sori in 1–3(–4) rows on each side of costae; pinnae 1–2.5(–3.5) cm wide.
               9. Sori in 1–3(–4) rows on each side of costae; pinnae 1–2.5(–3.5) cm wide; widespread _____ **S. fraxinifolium**
               9. Sori in 1 row on each side of costae; pinnae 0.7–1.3 cm wide; Amazon highlands (Tepuis) _____ **S. sessilifolium**

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BOOK REVIEW

ADAM CROSS. 2012. **Aldrovanda: The Waterwheel Plant.** (ISBN: 978-1-908787-04-0, cloth). Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, ENGLAND, U.K. (**Orders:** www.redfernnaturalhistory.com, sales@redfernnaturalhistory.com, +44 1202 686585). $29.72, 249 pp., 93 color photos, 6" × 9".

Most of us who have been around for a while probably grew up with the old adage, "You can't judge a book by its cover!" This reviewer says, "Oh, yes you can!—At least, a lot of the time!"

I was totally fascinated by the cover of this beautiful volume when I first saw it. Even more exciting, as I first thumbed through the pages, were the many color photographs and the careful, well-researched history of this unusual, one-of-a-kind plant.

Best of all, however, the author has provided us with an incredibly fascinating and carefully researched account of this monotypic genus and its only species, *Aldrovanda vesiculosa*, a Tertiary relict with an ancient lineage dating back "tens of millions of years." Cross has not only researched all the ancient information, he has provided a thorough presentation of Paleo-History; Morphology, Physiology and Ecology; and Habitat and Distribution, including all the continents in which *Aldrovanda* was and now is found. He also identifies areas where populations of *Aldrovanda* are currently "introduced and artificial" and discusses population genetics; conservation status, protection and national listings; integrated conservation and management guidelines; and cultivation.

As the author points out, "Despite being widely regarded as one of the most difficult carnivorous plants to maintain in horticulture, *Aldrovanda* is not as capricious as its reputation might suggest." He also offers advice on how to proceed with *Aldrovanda*, including the nurturing, protecting, and dealing with "pests, diseases, and predators."

This is a very careful, very well-researched account of *Aldrovanda*. The history and work of many prominent botanists through the centuries is fascinating, and the volume is concise, to the point, thoroughly explained, beautifully illustrated, and very well documented. Most dedicated gardeners and curious, causal gardeners will enjoy "trying their hands" with this plant. (And the author does tell you specifically how to get started at home!)—*Helen Jeude, Volunteer & Associate Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

TWO NEW SPECIES FROM THE BREVANTHERUM CLADE OF *SOLANUM* (SOLANACEAE) FROM EASTERN BRAZIL

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ABSTRACT

Two new species of *Solanum* (Solanaceae) from eastern Brazil are described. **Solanum anisocladum** Giacomin & Stehmann is similar to *S. megalochiton* Mart., but differs by the indument of the adaxial leaf surface, which is composed of long porrect-stellate and unbranched trichomes. It also has a more robust habit and a unique branching pattern of the flowering stems. It is restricted to the Atlantic Rainforest of northeastern Brazil and was previously misidentified as *S. megalochiton*. The other species, **Solanum caelicolum** Giacomin & Stehmann, is endemic to Espírito Santo state and is most similar to *S. hirtellum* (Spreng.) Hassl., but differs mainly by its adaxial leaf indument, with porrect-stellate trichomes with a central ray smaller than the lateral ones, by its comparatively larger fruiting calyx that can reach up to three times the diameter of the mature berry and by its sessile to subsessile unbranched congested inflorescence. Both species belong to the Brevantherum clade, one of the main lineages identified in the genus *Solanum*, and are placed together in a clade which contains species from *S.* sects. *Extensum* D'Arcy and *Stellatigeminatum* Child. Complete descriptions, distributions, and preliminary conservation assessments of the new species are given.

RESUMO

Duas novas espécies de *Solanum* (Solanaceae) são descritas para o leste do Brasil. **Solanum anisocladum** Giacomin & Stehmann é semelhante a *S. megalochiton* Mart., mas difere pelo indumento observado na face adaxial de suas folhas, composto por longos tricomas porrecto-estrelados associados a tricomas não ramificados, além de um hábito mais robusto, bem como um padrão de ramificação inusitado. A espécie é restrita às formações ombrófilas da Floresta Atlântica do nordeste do Brasil, e foi erroneamente determinada como *S. megalochiton*. A outra espécie, **Solanum caelicolum** Giacomin & Stehmann é endêmica do estado do Espírito Santo e é semelhante a *S. hirtellum* (Spreng.) Hassl. mas difere desta por seu indumento da face adaxial das folhas composto por tricomas porrecto-estrelados de raio central mais curto que os laterais, por seus lobos do cálice comparativamente mais longos, que podem atingir até três vezes o diâmetro do fruto maduro e por sua inflorescência não ramificada, congesta, séssil a subséssil. Ambas as espécies pertencem ao clado Brevantherum, uma das principais linhagens definidas para o gênero *Solanum*, e podem ser alocadas junto a um subclado que contém espécies das seções *Extensum* D'Arcy e *Stellatigeminatum* Child. Descrições completas, distribuições geográficas conhecidas e categoria de ameaça das espécies são apresentadas.

INTRODUCTION

Solanum L. (Solanaceae) is among the largest genera of flowering plants and contains approximately 1500 species with a worldwide distribution. Since 2004, it has been focus of a comprehensive species-level taxonomic inventory aiming to provide online descriptions of all its species (the PBI *Solanum* project; Knapp et al. 2004; http://www.solanaceaesource.org). This collaborative effort has led to the discovery of several new taxa from different countries (e.g., Peralta et al. 2005; Granados-Tochoy & Orozco 2006; Knapp 2007; Knapp & Nee 2009; Nee et al. 2006; Stern & Bohs 2009; Tepe & Bohs 2009; Knapp 2010a & b; Farruggia & Bohs 2011; Giacomin & Stehmann 2011; Vorontsova & Knapp 2012). The project was coincidentally developed together with

a large-scale initiative in Brazil to achieve the Target 1 of the Global Strategy for Plant Conservation adopted by the parties to the Convention on Biological Diversity (CBD) in 2002: the construction of a working list of the plant species for the country (Forzza et al. 2010). The construction of the Brazilian list of Solanaceae (Stehmann et al. 2010) revealed several poorly known or unknown taxa, and two of these are described here.

Previous molecular phylogenetic studies have identified the Brevantherum clade as one of the 12 to 15 main lineages of *Solanum* (Bohs 2005; Weese & Bohs 2007). This clade has been target of intensive studies by the authors in order to better understand the evolution of the group and the relationships among its species. It has a New World distribution, occurring from the southern United States through Argentina, with a center of diversity in Brazil. It comprises unarmed herbs to shrubs with unbranched to variously branched and stellate trichomes encompassing at least six sections treated in past classification systems. Molecular data have identified two subclades within the Brevantherum clade (see Weese & Bohs 2007 for more details). The first subclade comprises members of *S.* sect. *Gonatotrichum* Bitter, which are herbs to shrubs, mainly with an indument of unbranched trichomes (except for *S. lignescens* Fernald), and are easily characterized by the explosive dehiscence of their fruits (Stern & Bohs 2012; Stern et al. 2013). The other subclade contains species from five sections treated in past classifications (sects. *Brevantherum* Seithe, *Cernuum* Carvalho & Sheph., *Extensum* D'Arcy, *Lepidotum* Seithe and *Stellatigeminatum* Child), and all share branched to stellate or peltate hairs as a main character. Molecular phylogenies based on three gene regions (nuclear ITS and GBSSI and plastid *trnT-F*) indicate that *Solanum* sect. *Brevantherum* is largely monophyletic (L. Giacomin et al., unpub. data), but the monophyly of the other four sections has not been established and the relationships among them are uncertain. The limits of these sections are not well demarcated and they are in dire need of a revision, as pointed out by other authors (Child 1998; Nee 1999).

Although most recent classification systems place species with lepidote scales in *Solanum* sect. *Lepidotum* and species with large leaves and usually bristly-pubescent or scaly inflorescence axes in sect. *Cernuum*, there is no similar consensus about the characters defining *S.* sects. *Extensum* and *Stellatigeminatum* (Child 1998; Nee 1999). Child (1998) proposed that the concept of *S.* sect. *Extensum* should be applied only to climbing or sprawling species from Central America with somewhat foliaceous calyces and plurifoliate sympodia, even though the protologue for *S.* sect. *Extensum* did not list the sympodial structure as diagnostic (D'Arcy 1972). The species from South America with foliaceous calyces (a diagnostic character cited by D'Arcy, 1972), but with difoliate-geminate sympodial units were placed in *S.* sect. *Stellatigeminatum* by Child (1998). Nee (1999) disagreed with this proposition and, like D'Arcy (1972), included the species with foliaceous accrescent calyces and fasciculate axillary inflorescences in sect. *Extensum*. The entire Brevantherum clade is currently under investigation by the authors in order to better understand its infrageneric groupings.

While sampling the species of the Brevantherum clade from Brazil for phylogenetic studies, an undescribed species was revealed from Espírito Santo state. Also, while reevaluating the species limits of *Solanum megalochiton* Mart. from the northeast, a new segregate species was discovered. The new species do not have lepidote scales or scaly inflorescence axes, and are expected to belong to the undefined mixed clade to which the type species of sections *Extensum* and *Stellatigeminatum* are assigned.

MATERIALS AND METHODS

Material from the following herbaria was reviewed (acronyms from Index Herbariorum, http://sweetgum.nybg.org/ih/): BHCB, CEPEC, EAC, HUEFS, IPA, MG, MBML, PEUFR, RB and UFP, as well as the non-indexed HST at Recife, Brazil. Images of types were accessed through JSTOR Plant Science (http://plants.jstor.org) or collections websites from BM, F, G, M and P. We assessed the conservation status using IUCN Red List Categories and Criteria (IUCN 2010) and for the extent of occurrence calculation a minimum convex polygon (MCP) was used within ArcGIS software (ESRI). The terminology used to describe the vestiture and trichome types was based on Roe (1971) and Mentz et al. (2000). The delimitation of the new taxa was based on a morphological species concept where the species is recognized as distinct if possessing a unique suite of characters and separated from its similar species by morphological gaps (Mallet 1995).

RESULTS

Taxonomic Treatment

Solanum anisocladum Giacomin & Stehmann, sp. nov. (**Figs. 1, 2A–F, 3A–D**). Type: BRASIL. Pernambuco: Mun. Jaqueira, RPPN Frei Caneca, Serra do Urubu, trilha da Mata da Caranha, topo da serra, 08°42'52.5"S, 35°50'54"W, 700 m, 31 Mar 2012 (fl, fr), *L.L. Giacomin et al. 1794* (holotype: BHCB [BHCB002730]; isotypes: NY, RB, UFP, UT).

Solanum anisocladum differs from *Solanum megalochiton* Martius by its more robust habit tending to form small trees up to 5 m with a prominent trunk, while *S. megalochiton* is mostly a shrub up to 3 m branched from near the base; its hirsute indument mainly composed of long trichomes (up to 2.6 mm; Fig. 2A–B), with the older stems becoming hispid due to the remnants of the stalks of the stellate trichomes (observed both in fresh and dried specimens), these mostly soft and up to 1.5 mm in *S. megalochiton*; the always shiny adaxial leaf suface, even in dry material, with a vestiture of unbranched (Fig. 2D), porrect-stellate, and always eglandular hairs, vs. adaxial leaf surfaces dull, with stellate and frequently glandular hairs in *S. megalochiton*; and by its unusual branching, with a strong change in stem growth direction where the inflorescence arises between the nodes, whereas *S. megalochiton* has straight branches.

Shrubs to small trees up to 5 m, usually with a prominent trunk, branching in the upper stems, these spreading. Young stems moderately to densely hirsute to hispid with few-rayed (4–6) porrect-stellate trichomes, these sometimes multangulate, on multiseriate stalks 0.3–1.2 mm long, the rays 0.2–0.8 mm, usually with a 2–3-celled central ray longer than the 1-celled lateral ones; old growth glabrescent to pubescent, usually with broken trichomes comprising a hispid vestiture of multiseriate stalk remnants. Bark of older stems yellowish-white, usually shiny; new growth whitish-green to dark purple near the insertion of the inflorescence, always shiny. Sympodial units usually trifoliate, rarely di- or plurifoliate, often with solitary leaves; if geminate, leaves paired only at branching points and differing mainly in size, the smaller up to ⅓ the size of the larger ones. Leaves simple, the blades 1.7–11.8(–13) cm long, 1.2–4.8 cm wide, narrowly elliptic to ovate-elliptic, membranaceous, weakly discolorous (dark shiny green above, pale green beneath when fresh), the abaxial surfaces moderately to densely hirsute, the lamina always visible, with short- (more often on the lamina) to long-stalked (more often on primary and secondary veins) porrect-stellate trichomes with 3–5 lateral rays supported by a multiseriate stalk 0.3–0.9(–1.4) mm and a 2–3 celled central ray somewhat longer than the lateral ones (Fig. 2B), 0.8–1.2 mm long, the adaxial surfaces moderately to densely hirsute, the lamina always visible, with mixed hyaline unbranched trichomes (Fig. 2D) up to 1.8 mm long, and sessile (more often on the lamina) to short-stalked (more often on primary and secondary veins) multangulate-stellate trichomes, frequently with few (1–4; Fig. 2C) lateral rays and a 2–3-celled central ray much longer than the others, 0.8–2 mm long and supported by a multiseriate stalk up to 0.4 mm long; venation camptodromous, impressed or not above (barely visible in dried material), raised beneath, the secondary veins 5–9 pairs; base rounded to cuneate, asymmetric; margins entire, slightly revolute; apex acute to long attenuate-caudate (only acute on the smaller geminate leaves); petioles 1.8–5.5 mm long, densely hirsute, with the same trichomes as those of the abaxial midrib. Inflorescence an elongated unbranched cyme, terminal, lateral, internodal, or subopposite the leaves, when internodal, changing the orientation of the branch (see comments; Figs. 1, 3A–B), the axes (0.35–)0.9–4.3 cm long, with (3–)6–15 flowers, subsessile to pedunculate, the peduncles 0.1–1.47 cm long, moderately hirsute with porrect-stellate trichomes like those of the stems, the rachis pale green, densely pubescent with three types of trichomes: hyaline, unbranched, 2–4-celled, eglandular or glandular-capitate trichomes, sessile to short-stalked multangulate-stellate trichomes with few (1–4) lateral rays or only the 2–4-celled, sometimes glandular-capitate central ray developed, this much longer than the others, and supported by a multiseriate stalk up to 0.4 mm long, and long-stalked porrect-stellate trichomes like those of the peduncle with stalks up to 0.9 mm long; pedicels 0.3–1.2 cm long in flower, 1.9–2.5 cm in fruit, pale green to dark pink to purplish at base, articulated at base, 1 mm in diameter at base, densely pubescent with the same unbranched trichomes found on the rachis, almost all with a glandular head, up to 2 mm long, mixed with sessile to short-stalked multangulate trichomes with 1–4 lateral rays and a longer central ray. Buds slightly elongated with developed calyx lobes, the corolla nearly included even when fully developed. Flowers perfect, 5-merous. Calyx tube 1–2 mm long, with lanceolate to narrow-ovate lobes 6–8 mm long, 3–4 mm wide in flower, the apices acuminate, strongly accrescent in fruit, the lobes broadly ovate to cordate, 8.6–12 mm long, 8–10 mm wide, the apices acute, densely covered abaxially with the same trichome types of the rachis, but the porrect-stellate hairs with

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FIG. 1. Holotype of *Solanum anisocladum* Giacomin & Stehmann. (*L.L. Giacomin et al. 1794*, BHCB [BHCB002730]). Specimen image reproduced with the permission of the BHCB Herbarium, Departamento de Botânica, ICB, Universidade Federal de Minas Gerais.

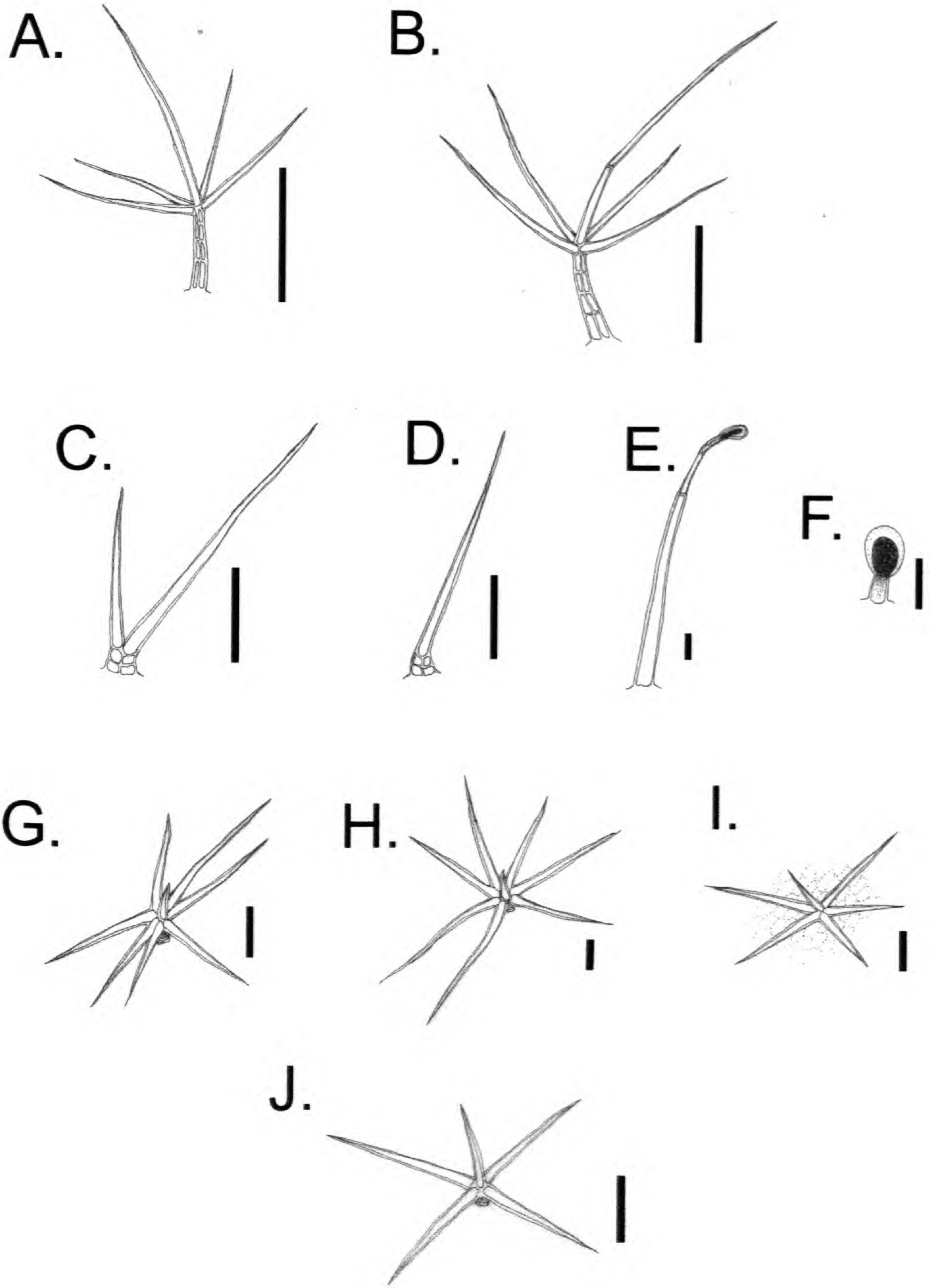


FIG. 2. Hair types of **A–F:** *Solanum anisocladum* Giacomin & Stehmann [all from *L.L. Giacomin et al. 1794* (BHCB)]. **A.** Porrect-stellate hair of the stem. **B.** Porrect-stellate long-stalked hair of the abaxial leaf surface. **C.** Furcate hair of the adaxial leaf surface. **D.** Unbranched hair with a multicellular base of the adaxial leaf surface. **E.** Multicellular unbranched glandular capitate hair with an ellipsoid glandule of the adaxial calyx surface. **F.** Glandular globose hair on adaxial calyx surface. **G–J:** *Solanum caelicolum* Giacomin & Stehmann [G–I from *V. Demuner et al. 4253* (BHCB), J from *V. Demuner et al. 3273* (BHCB)]. **G.** Porrect-stellate short-stalked hair from stem. **H.** Porrect-stellate hair with a very reduced midpoint from abaxial leaf surface. **I.** Porrect-stellate sessile hair from adaxial leaf surface. **J.** Porrect-stellate hair with a subequal rays from adaxial calyx surface. Scale bars: A–D = 500 µm; E–J = 100 µm.

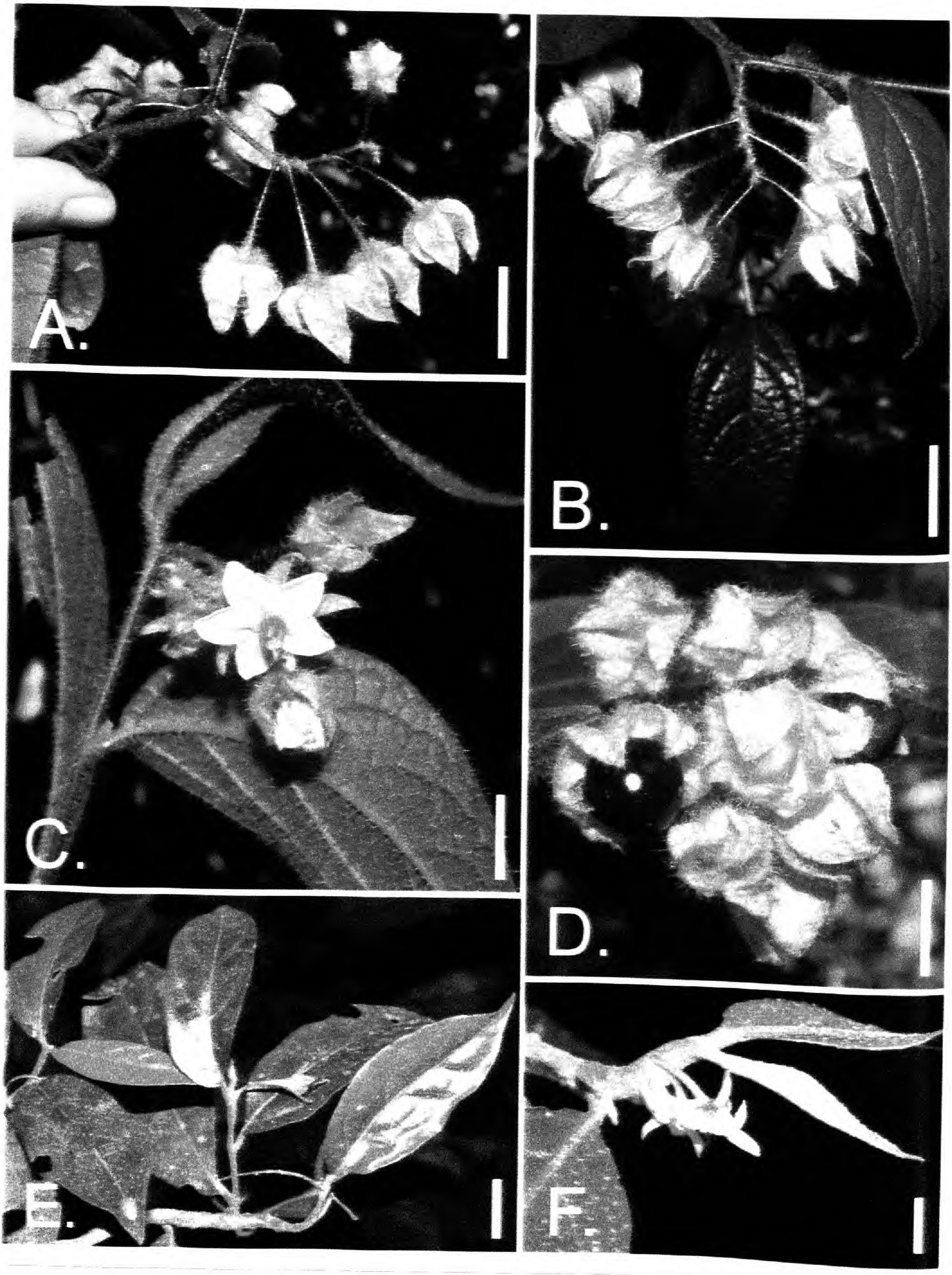


FIG. 3. A–D: *Solanum anisocladum* Giacomin & Stehmann [field pictures of *L.L. Giacomin et al. 1794* (BHCB)]. **A.** The unusual branching pattern diagnostic of *S. anisocladum* Giacomin & Stehmann (see comments). **B.** The robust inflorescence and the change in branch direction where the inflorescence arises near the leaf. **C.** Stellate spreading corolla and calyx. **D.** Mature fruit. **E–F:** *Solanum caelicolum* Giacomin & Stehmann [field pictures of *L.L. Giacomin et al. 1852* (BHCB)]. **E.** Immature fruit. **F.** Congested sessile cyme. Scale bars: A–C and E = 1 cm; D = 1.5 cm; F = 0.5 cm.

shorter stalks and the central ray always longer than the others and often glandular, adaxially with unbranched 2–4-celled (sometimes with a poorly developed secondary ray) glandular capitate trichomes up to 2 mm long (Fig. 2E), the gland ellipsoidal, these commonly found also on the margin, associated with sessile to subsessile globose dark glandular trichomes (Fig. 2F), these concentrated on the midveins and near the base. Corolla 1.3–1.7 cm in diameter, white, stellate, lobed up to ¾ to the base, the lobes 4–6 mm long, 4.5–6.5 mm wide, deltoid to ovate, with acute, slightly involute apices, spreading at anthesis, sparsely to moderately pubescent abaxially with the same trichome types found adaxially on the calyx and with a tuft of small unbranched eglandular trichomes at apex, glabrous adaxially. Filament tube up to 1 mm long, with a minute free portion less than 1 mm long, glabrous; anthers 2.8–4 mm long, 1.3–1.5 mm wide, sometimes slightly unequal, elliptic to oblong, connivent, yellow, glabrous on both faces, poricidal at apex, with the pores directed introrsely, opening into longitudinal slits with age. Ovary glabrous; style 6–7 mm long, cylindrical; stigma clavate, with a papillose surface. Fruit a globose berry 1–1.4 cm in diameter, white to pale green when immature, purple to black when mature, shiny, glabrous, drying brown to dark, completely covered by the accrescent calyx which spreads open at maturity. Seeds 9–31(–35) per fruit, 2.3–3.4 mm long, 1.7–2.3 mm wide, flattened, reniform, golden to brown, the surfaces with irregular pits.

Additional specimens examined. **BRASIL. Alagoas:** Mun. Murici, Poço D'Anta, ca. 16–19 km NNW of Murici by road, Mata de Murici, 9°13.53'S, 35°52.776'W, 550–600 m, 14 May 2001 (fl, fr), *W.W. Thomas et al. 12441* (BHCB, NY, RB). **Bahia:** Mun. Ibirapitanga, Faz. Paineiras, 17 Feb 1998 (fl, fr), *A.S. Conceição 213* (MG). **Pernambuco:** Mun. Maraial/Lagoa dos Gatos, Serra do Urubu, 20 Apr 1994 (fl, fr), *A.M. Miranda & L.P. Felix 1628* (EAC, HST).

Discussion.—Solanum anisocladum is a species with a robust habit, forming small trees up to 5 m tall with prominent trunks, with the upper leaf surface shiny, dark green, and drying dark. It is similar to *Solanum megalochiton* which normally forms much branched shrubs up to 3 m tall, with the surface matte, often covered by a whitish-yellow indument, and normally pale green when dried. Both species share an inflated calyx that is strongly accrescent at fruit maturity (Fig. 3D). This feature was previously used to separate *S. megalochiton* from similar species such as *S. didymum* Dunal. However, *S. anisocladum* presents several other characters that readily distinguish it from *S. megalochiton*. Its indument of very long stellate and unbranched hairs reaching more than 2 mm long and drying ferruginous (Figs. 1, 2A–B) is easily visible to the naked eye. The old growth becomes somewhat hirsute to hispid where only the multiseriate stalks of the stellate trichomes remain. The indument in *S. megalochiton* is much softer, reaches up to 1.5 mm long, is normally transparent to yellowish when dried, and the stems never become hispid. The inflorescence is also a distinctively robust unbranched cyme (Fig. 3A–B), sometimes with an axis reaching more than 4 cm long, whereas the inflorescences of *S. megalochiton* are normally shorter than 2.5 cm. Its adaxial leaf indument is composed of eglandular porrect-stellate trichomes associated with unbranched hairs, the latter with multicellular bases, apparently representing stellate hairs without developed lateral rays. The adaxial leaf indument of *S. megalochiton* is composed only of stellate hairs, these sometimes glandular. *Solanum anisocladum* also has a distinctive branching pattern not observed in *S. megalochiton* (Fig. 3A). When arising from between the nodes, the inflorescences can invoke a strong change in growth direction (not always visible on small branches in herbarium sheets, but observed in every specimen seen at the field). In contrast, the flowering branches of *S. megalochiton* are more or less straight.

In the Brazilian plant species list (Stehmann et al. 2010), *Solanum megalochiton* was cited as occurring in northeastern Brazil from the states of Alagoas and Bahia. During visits to herbaria in Pernambuco and Bahia no specimens matching it were seen co-occurring with *S. anisocladum*. A sheet from Alagoas (*Thomas 12441*; BHCB, NY, RB) determined as *S. megalochiton* by other *Solanum* experts actually conforms to our concept of *S. anisocladum*. Thus, in northeastern Brazil, *S. megalochiton* is known to occur only in a few locations in the wet forests of the southern part of Bahia and not further northward. *Solanum megalochiton* can also be found in all states of the southeastern and southern regions of Brazil, with a few additional collections in the state of Goiás and Mato Grosso. This suggests that *S. anisocladum* and *S. megalochiton* are not sympatric, but this cannot be confirmed because not all important collections of the group from the northeast have been seen at present (e.g., JPB).

Etymology.—The name *Solanum anisocladum* was given because of the peculiar branching pattern resulting in unequal branches when the inflorescence arises from between the nodes.

Distribution and habitat.—*Solanum anisocladum* occurs in forest edges of the Atlantic coastal rainforest of northeastern Brazil in the states of Alagoas, Bahia, and Pernambuco, in partial to complete shade, at elevations of 500–700 m (Fig. 4). Primary wet forest fragments at this elevation are quite rare in northeastern Brazil today, and the type collection, despite the fact that it was found in a forest edge, was from a well preserved fragment.

Phenology.—The species was collected with flowers and fruits from February through May, but a flowering peak was observed in February and March, and fully developed fruits were found from March through May.

Preliminary conservation status.—Endangered B1 a,b (i, ii, iii, iv). *Solanum anisocladum* is known from only three localities and its calculated extent of occurrence using the MCP is 834 km^2. Despite the fact that the Bahia registry is far from the one in Pernambuco state, the MCP reflects the narrow range of coastal rainforest where the species is expected to occur. Although the type locality is now part of a private reserve owned by a sugar company (RPPN Frei Caneca), it consists of a small group of forest fragments in a severely damaged landscape mainly modified by extensive agriculture based on monoculture (plantations). Generally, the Atlantic coastal rainforest has been severely damaged in northeastern Brazil in the past decades due to urban expansion and extensive farming.

Solanum caelicolum Giacomin & Stehmann, sp. nov. (**Figs. 2G–J, 3E–F, 5**). TYPE: BRASIL. ESPÍRITO SANTO: Colatina, Alto Moacir, Prop.: Lalau (property of Sr. Landislau), 19°29'37"S, 40°33'08"W, 200 m, 20 Mar 2007 (fl, fr), *V. Demuner et al. 3273* (HOLOTYPE: MBML; ISOTYPE: BHCB [BHCB002734]).

Differs from *Solanum hirtellum* (Spreng.) Hassl. by its adaxial leaf and calyx indument, with porrect-stellate trichomes always with a one-celled central ray much smaller than the lateral ones; in *S. hirtellum* the central ray of the stellae on adaxial leaf surfaces is mostly longer than the lateral rays. *Solanum caelicolum* also differs in its sessile to subsessile congested inflorescences that are much shorter and never branched (Fig. 3F), with the pedicels arising very close to each other, in contrast to the pedunculate, lax (the pedicels well-separated from each other), sometimes several-branched inflorescences of *S. hirtellum*. *Solanum caelicolum* has a comparatively larger calyx, with the lobes reaching up to three times the fruit diameter at maturity; the calyx lobes in *S. hirtellum* are not larger than the berry at maturity.

Shrubs, up to 3 m, sometimes scandent, much branched, the apical branches scandent, held downwards, arching. Young stems densely pubescent with sessile to short-stalked porrect-stellate trichomes normally with 8 lateral rays, rarely fewer, commonly of unequal length, up to 0.3 mm long, with a central ray much shorter than the lateral ones (Fig. 2G); old growth sparsely pubescent to glabrescent. Bark of older stems bright white to yellowish, shiny; new growth gray due to dense vestiture, with a white to dark purple lamina beneath. Sympodial units 2–3 foliate, geminate, with paired leaves differing in size and shape, the smaller ones less than ¼ of the size of the larger. Leaves simple, the blades 2.2–7 cm long, 1–3 cm wide, elliptic to broadly elliptic (the smaller geminate leaves broadly elliptic to ovate, sometimes slightly obovate), membranaceous to chartaceous, slightly discolorous, drying dark adaxially, the abaxial surfaces sparsely to moderately pubescent, the pubescence denser on veins, with sessile to short-stalked porrect-stellate trichomes with 4–9 lateral rays up to 0.3 mm long, frequently unequal in length, and a minute central ray (Fig. 2H), always shorter than the laterals, up to 0.1 mm long, the stalks multiseriate, reaching 0.1 mm long, the adaxial surfaces glabrescent, with hairs only on the veins or sparsely pubescent on the lamina, with sessile porrect-stellate trichomes with 4–8 lateral rays (trichomes observed on veins frequently more rayed), up to 0.3 mm long, frequently unequal, with a slightly longer central ray than on the abaxial surface (Fig. 2I), reaching 0.2 mm long, but still shorter than the lateral ones; venation camptodromous, slightly to not raised above, raised beneath, the secondary veins 4–6 pairs; base cuneate to obtuse (rounded on the smaller geminate leaves), asymmetric; margins entire, plane; apex long-attenuate to acuminate (obtuse to rounded on the smaller geminate leaves); petioles 2.3–5 mm long, densely pubescent with the same trichomes as the stem and abaxial midrib. Inflorescence a congested unbranched cyme, lateral, internodal, or subopposite the leaves, rarely terminal, the axis sessile to subsessile, up to 3 mm long, the peduncle up to 1 mm or absent, green, moderately to densely covered with the same porrect stellate trichomes as the stem, the rachis barely visible to absent, with the pedicels very closely spaced; pedicels

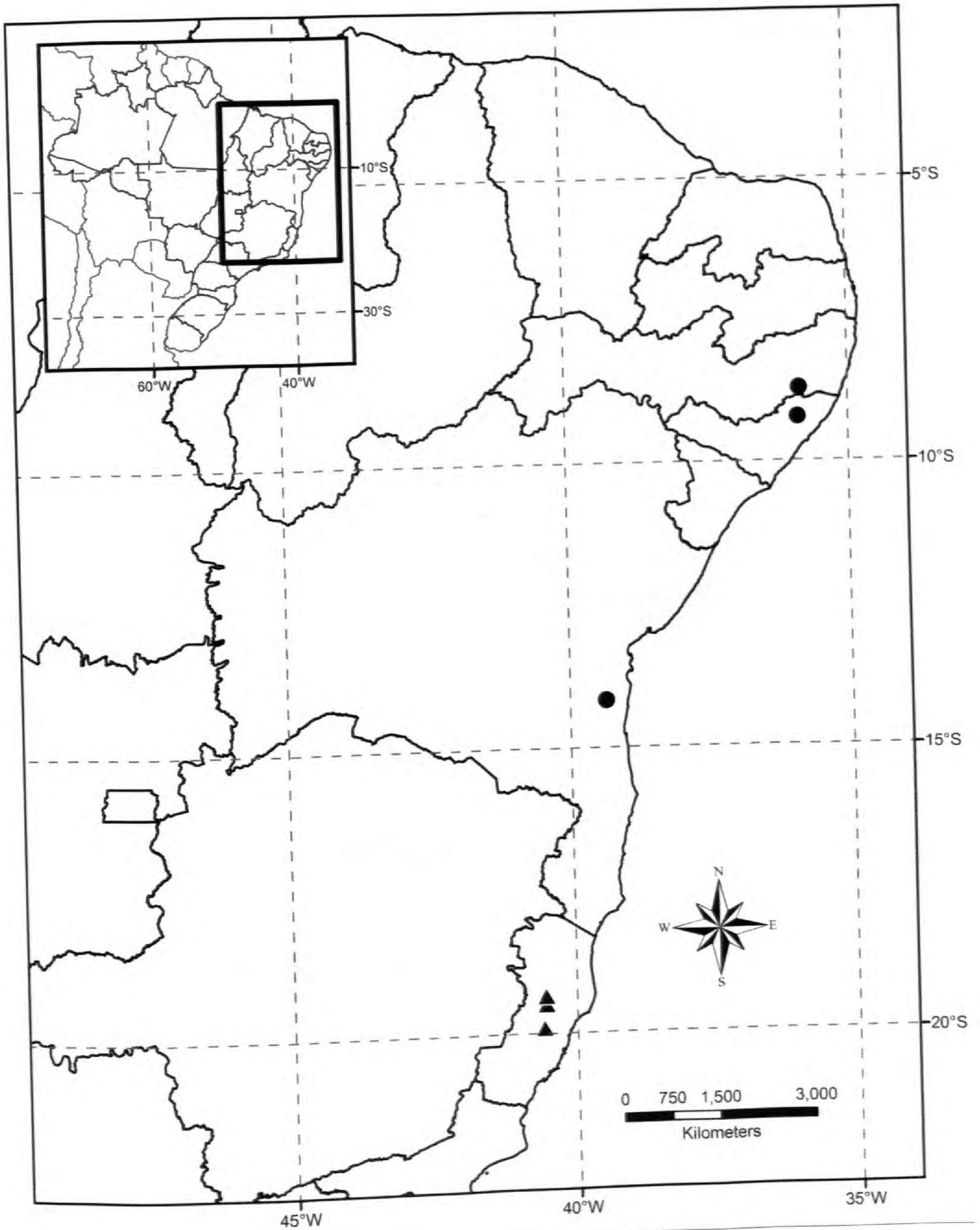


Fig. 4. Known distribution of *Solanum anisocladum* (circles) and *S. caelicolum* (triangles) in eastern Brazil.



FIG. 5. Isotype of *Solanum caelicolum* Giacomin & Stehmann. (*V. Demuner et al. 3273*, BHCB [BHCB 002734]). Specimen image reproduced with the permission of the BHCB Herbarium, Departamento de Botânica, ICB, Universidade Federal de Minas Gerais.

3–8 mm long in flower, 5–9 mm in fruit, green at base, becoming purplish distally, articulated at base, less than 1 mm in diameter at base, moderately to densely pubescent with sessile to subsessile porrect-stellate trichomes with up to 8 lateral rays, the central ray much shorter than the others, and sometimes with 3–4 celled uniseriate glandular hairs near the calyx. Buds globose, the corolla emergent from the calyx lobes, spreading just before anthesis. Flowers perfect, 5-merous. Calyx tube up to 1 mm long, with narrow oblong to lanceolate lobes 1.6–2.5 mm long, 0.7–1 mm wide in flower, 2.5–3 mm long, 1–1.2 mm wide in fruit, with acute to acuminate apices, becoming ovate, accrescent, but not covering the whole mature berry, covered abaxially with the same porrect-stellate trichomes found on the pedicels, associated with unbranched 3–4-celled glandular capitate trichomes, barely visible in dried material, adaxially with sparse porrect-stellate trichomes, smaller than those found abaxially, with 4–7 lateral rays, often the same size as the central ray (Fig. 2J), associated with unbranched glandular capitate trichomes at the base near the ovary, and also with a tuft of unbranched eglandular trichomes at the calyx lobe apices. Corolla 0.8–1 cm in diameter, white, stellate, lobed up to ¾ its length, the lobes 3.2–3.8 mm long, 1.8–2.2 mm wide, ovate to elliptic, with acute to acuminate apices, spreading at anthesis, moderately pubescent abaxially with the same porrect-stellate trichomes as the adaxial calyx surface, with a central ray the same size or sometimes longer than the lateral ones, associated with minute one-celled unbranched or sometimes forked, sometimes glandular hairs densely covering the margins, glabrous adaxially. Filament tube up to 0.5 mm, with a free portion reaching 0.6 mm, sometimes slightly unequal, glabrous; anthers 1.6–2 mm long, 0.7–1 mm wide, elliptic, connivent, yellow, glabrous abaxially, with unbranched, forked, or sometimes stellate eglandular trichomes adaxially, these erect or mostly lying flat, pointing upwards, poricidal at apex, the pores directed introrsely, opening into longitudinal slits with age. Ovary glabrous; style 1.8–3 mm long, stigma cylindrical, slightly clavate, with a papillose surface. Fruit a globose berry, 0.7–0.9 cm in diameter, white to pale green when immature, purple at maturity, shiny, glabrous, drying brown to dark, initially covered by the accrescent calyx that spreads at maturity. Seeds few (2–3 observed in mature fruits), 2.5–3 mm long, 2–2.4 mm wide, flattened, reniform, pale brown, the surface with irregular pits.

Additional specimens examined. **BRASIL. Espírito Santo:** Mun. Marilândia, Liberdade, Água Viva, Pedra do Cruzeiro, prop.: Aguilar A. Lorencini, 19°20'53.7"S, 40°33'03.6"W, 150 m, 19 Jan 2006 (fl, fr), *V. Demuner et al. 1697* (MBML); same locality, 19°20'45"S, 40°32'57"W, 300 m, 13 Jun 2007 (fr), *V. Demuner et al. 4253* (BHCB, MBML); Mun. Santa Teresa, Comunidade de Santo Antônio, propriedade do Sr. Boza, fragmento de floresta ombrófila densa, após plantação de eucalipto, à direita da entrada, descendo o vale, 19°54'32.3'S, 40°35'25.6"W, 740 m, 8 Jun 2012 (fl, fr), *L.L. Giacomin et al. 1852* (BHCB, NY, RB, UT); Mun. Santa Teresa, São Lourenço, Reserva Biológica de São Lourenço, Trilha do Caravagem, 750 m, 3 Feb 1999 (fl), *L. Kollmann et al. 1810* (MBML, RB); Mun. Santa Teresa, Santo Antônio, Terreno do Boza, Mata de encosta, 850 m, 31 Mar 1999 (fl, fr), *L. Kollmann et al. 2355* (BHCB, MBML, RB); Mun. Colatina, Sapucaia, Alto Moacir, Terreno do Lalau, 18 Apr 2008 (fl), *L. Kollmann et al. 10914* (BHCB, MBML); Mun. Colatina, Alto Moacir, Pedra do Cruzeiro, propr.: Landislau, 19°18'39"S, 40°31'75" [label data] W, 150 m, 22 Feb 2006 (fl, fr), *L.F.S. Magnago et al. 738* (BHCB, MBML).

Discussion.—Solanum caelicolum resembles *S. hirtellum*, sharing with it a similar habit and stem indument, leading to misidentifications of collections from Espírito Santo state in the past. It can be distinguished by its elliptic leaves, not ovate like those of *S. hirtellum*, that are glabrescent and usually drying dark adaxially (normally moderately pubescent and pale green in *S. hirtellum*), abaxially drying somewhat gray to pale green due to the conspicuous indument (normally inconspicuously pubescent and pale green in *S. hirtellum*). The adaxial leaf trichomes are also distinct from those of *S. hirtellum*. While *S. caelicolum* has porrect-stellate trichomes with a very reduced midpoint (central ray; Fig. 2H), *S. hirtellum* mostly has stellae with the central ray sometimes multicellular and longer than the lateral rays on the upper leaf surfaces. Some variation in trichome morphology occurs in *S. hirtellum*, but at least some of the hairs of the adaxial leaf surfaces have a central ray longer than the lateral ones. *Solanum caelicolum* also has a distinctive sessile to subsessile congested and unbranched inflorescence (Fig. 3F) with the pedicels arising very close to each other (the rachis almost absent), whereas the inflorescence in *S. hirtellum* is mainly pedunculate, few- to many-branched, and lax, with the pedicels arising up to 0.5 cm from each other. Pedicel size can also be used to distinguish both species; they are up to 8 mm long in *S. caelicolum* and frequently exceed 8 mm in *S. hirtellum*. Another good character to distinguish the two species is the size of the fruiting calyx lobes. In *S. caelicolum* the calyx lobes are larger than the diameter of the mature berry, whereas in *S. hirtellum* the calyx lobes are shorter than the mature berry.

Both species are known from Espírito Santo state, but they apparently do not co-occur. While *S. caelicolum* seems to be restricted to north-central Espírito Santo, *S. hirtellum* has a much broader distribution, extending from northeast Argentina and Paraguay and reaching its northernmost limit in the south of Espírito Santo.

Etymology.—The epithet *caelicolum* derives from the Latin "dweller of heaven." It references the region of Santa Teresa and surroundings, where the species was first collected and is most abundant. The region holds a considerable amount of the preserved forest fragments of the Espírito Santo state and plays an essential role in the conservation of the plant species of the Brazilian Atlantic Forest, a severely damaged biome due to human occupation. For *Solanum* specialists as well as other botanists, it is a heaven of plant diversity and new species.

Distribution and habitat.—*Solanum caelicolum* inhabits the understory or shaded forest edges of well-preserved fragments of the Brazilian Atlantic coastal rainforest, and is known only from Espírito Santo state from 150 to 850 m (Fig. 4). Despite the fact that the type collection was from an outcrop, the species is believed to inhabit only shaded environments and the reference might be to a granitic boulder in the forest understory, a common situation in Espírito Santo forests.

Phenology.—The species can be found in flower from January through June. Fruits were found from February through June, but fully developed ones were found from March through June.

Preliminary conservation status.—Endangered B1 a,b (i, ii, iii). *Solanum caelicolum* is known from four localities very close to each other in the state of Espírito Santo, and its calculated extent of occurrence using the MCP is 31 km^2. At the municipality of Santa Teresa, the locality of three of the collections, there still are several well preserved forest remnants, some of them within protected reserves. One of the collections was found at a city reserve (Estação Biológica de São Lourenço) and therefore we are not treating this species as critically endangered. The populations from further north in the Colatina region are more susceptible to changes in the species area of occupancy due to urban expansion and farming.

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BOOK REVIEW

TIMOTHY A. BLOCK AND ANN FOWLER RHOADS. 2011. **Aquatic Plants of Pennsylvania: A Complete Reference Guide.** (ISBN: 978-0-8122-4306-2, cloth). University of Pennsylvania Press, Hopkins Fulfillment Services, P.O. Box 50370, Hampden Station, Baltimore, Maryland 21211, U.S.A. (**Orders:** www.upenn.edu/pennpress, 1-800-537-5487, 1-410-516-6998 fax). $59.95, 320 pp., 93 color illus., 508 b/w illus., 7" × 10".

Most flower enthusiasts love the plants they know and spend hours tending to their personal gardens and yards. Many spend time helping their local herbarium and surroundings. It's a Labor of Love, and we are more than willing to help in any ways we can. The authors of this volume carefully explain the "Purpose of the Book" in the opening paragraph of the Preface. In very short time, we are in Chapter 1. Evolution and Ecology—and we are totally "hooked." (*Fascination* is probably a more accurate—and scholarly!—designation.) The result is the same. We are definitely intrigued by this book. Your hubby or wife calls to you, asking when dinner will be ready. The engrossed reader responds with "Uh, Honey, there's a big frozen pizza in the 'fridge'—put it in the oven and we'll have that for supper!" (I wonder how many of our readers will immediately identify with that one?!)

While many of us have probably seen a few water lilies and bulrushes and perhaps curly pondweed, most of us are not at all familiar with the plants, their habits, and how they actually grow. In addition to the usual descriptions of the various plants, the authors utilize line drawings, color photographs, and a drawing of the state of Pennsylvania, with a red line indicating the route being examined and a "fill in" of dark blue dots to indicate the presence of lakes. Such maps are also used to show the routes and places in Pennsylvania where specific plants were located.

They also explain the types of ecosystems, the management of aquatic ecosystems (endangered, threatened, rare, undetermined candidate), or watch list by the Pennsylvania Natural Heritage Program (at that time). Table 1.2 lists the Endangered, Threatened, and Rare Aquatic Plants of Pennsylvania. In addition, the authors created a table of Non-native, Invasive Aquatic Plants in Pennsylvania as well as a proliferation of "over-abundant native species."

In Chapter 2, the authors have created Identification Keys for the Aquatic Plants of Pennsylvania. They explain the system they have devised and how to use the keys they have developed. In addition, they include line drawings in areas that might be more difficult to visualize. The keys are designed to be as helpful as possible. The authors really did a great job. These keys may not appear to be the keys you've been accustomed to using, but they do a terrific "either/or" approach which probably works a lot better for this type of identification.

The balance of the volume describes the various types of plants, their family, the species, accompanying line drawings of the plant described, and the map of Pennsylvania showing the route, the locations, and sometimes an accompanying comment.

This volume is fun to peruse, beautiful to see the color photos, easy to use the keys, easy to understand the line drawings, and also creates an urgent desire in the reader to go immediately to Pennsylvania and travel those map routes!—*Helen Jeude, Volunteer & Associate Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

NEW SPECIES OF *APHELANDRA* (ACANTHACEAE) FROM PERU AND ECUADOR

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ABSTRACT

Six new species of *Aphelandra* are recognized from Peru and Ecuador. They are the following: **Aphelandra plowmanii** Wassh., **A. knappii** Wassh., **A. davidsonii** Wassh., **A. aucayacuensis** Wassh. and **A. schunkei** Wassh. from Peru and **A. espinosae** Wassh. from Ecuador.

RESUMEN

Se reconocen seis nuevas especies de *Aphelandra* de Perú y Ecuador. Son las siguientes: **Aphelandra plowmanii** Wassh., **A. knappii** Wassh., **A. davidsonii** Wassh., **A. aucayacuensis** Wassh. y **A. schunkei** Wassh. de Perú y **A. espinosae** Wassh. de Ecuador.

Aphelandra, a neotropical genus of about 230 species which extends from northwestern Mexico southeastward through regions of both wet and dry forests to the state of Santa Catarina in southeastern Brazil and to the province of Salta in southwestern Argentina. No native specimens of the genus are found in the West Indies. In the number of species and in morphological diversity the genus reaches its zenith in the Andean mountains of western South America and in Brazil. Presently, 61 species have been described from Colombia, 41 species from Ecuador, 38 species from Peru and 44 species from Brazil. Like most Acanthaceae, they are found to be of extremely local distribution and range, only 15% are found to be more widespread, in undisturbed forests and are rarely forests and are rarely collected in secondary growth.

The genus is distinguished from other Acanthaceae genera by being devoid of cystoliths, the familiar character by which most acanthaceous plants are recognized, by having 4 stamens with narrow, 1-thecous anthers and by having ellipsoidal pollen grains bearing 3 longitudinal clefts, each of which often possess one pore. Its flowering spikes are often large and showy, including the bracts and bractlets, and in certain species variegated or colored leaves occur. Important characters in the genus, which link large series of species, are the presence or absence of spiny intepetiolar bracts, of teeth, spiny or otherwise, on the margins of the leaf blades or flower bracts, and of ocelli on the flower bracts.

The nearest relative is probably the Old-World genus *Crossandra*, consisting of about 50 species from Africa and Asia. In *Crossandra*, the upper corolla lip is absent or the corolla is dorsally deeply cleft, whereas in *Aphelandra* the upper lip always present.

Aphelandra plowmanii Wasshausen, sp. nov. (**Fig. 1A–E**). TYPE: PERU. LORETO. Prov. Maynas: Río Ampiyacu, Pebas and vicinity, 3°10'S, 71°49'W, 10 Apr 1977, *T. Plowman, R.E. Schultes & O. Tovar 6732* (HOLOTYPE: US).

Unbranched shrub or treelet 1.5–2 m tall; stem terete to subquadrate, glabrous below, the upper portion densely hirsute, the trichomes appressed, 1–1.5 mm long. Leaves sessile or short-petiolate, the petioles 5–40 mm long, hirsute, the blades oblanceolate, 22–40 cm long, 7.5–12 cm wide, acuminate at apex, gradually narrowed from the middle or slightly above the middle and decurrent at base, the veins (12–14 pairs) puberulous, prominent beneath, less so above, the upper surface a darker green than the lower surface, both sparingly and inconspicuously puberulous, the margin entire or slightly undulate. Inflorescence a solitary, terminal, sessile or subsessile spike 12–19 cm long and 4–5 cm broad (excluding corollas), moderately dense, the rachis sparingly pubescent with appressed trichomes to 1 mm long, the flowers opposite to subopposite along the spike axis; bracts bright orange, recurving, broadly elliptic, 33–43 mm long, 17–18 mm wide, acute to rounded at

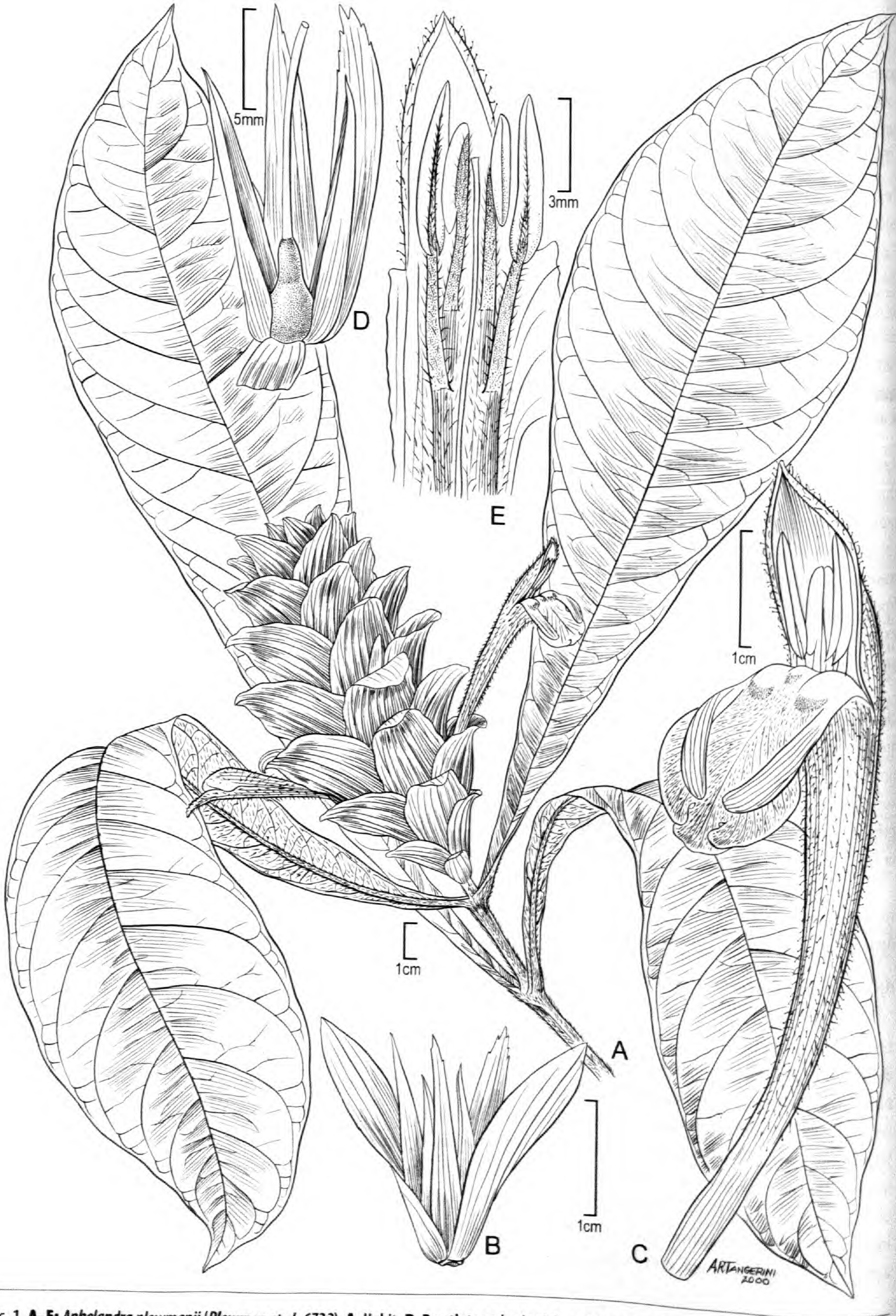


FIG. 1. **A–E:** *Aphelandra plowmanii* (*Plowman et al. 6732*). **A.** Habit. **B.** Bractlets and calyx lobes. **C.** Corolla. **D.** Calyx lobes, ovary and pistil. **E.** Corolla opened showing attachment of filaments and anther thecae.

apex, attenuate basally, glabrous, rather firm, distinctly parallel veined, margin entire; bractlets elliptic to oblanceolate, 20–22 mm long, 3–3.5 mm wide, glabrous, acute and reticulately veined apically; calyx deeply lobed, 17–20 mm long, the lobes lanceolate, the posterior segment larger, 20 mm long and 4 mm wide, somewhat erose at apex, the anterior pair 19–20 mm long and 3.5 mm wide, the lateral pair 17 mm long and 3 mm wide, all glabrous and subhyaline; corolla white tinged with magenta on lower lip or the tube carmine red, lip yellow with two dark-red spots at throat, 80 mm long, tomentose, especially on the upper part of the tube, throat and upper lip, the tube curved, 2.5 mm wide at base then gradually enlarged to 7 mm at throat, the upper lip erect, ovate, 22–25 mm long and 3.5–4 mm wide, entire and cucullate at apex, lower lip spreading, 3-lobed, the middle lobe obovate, 14 mm long and 1.75–2 mm wide, truncate at tip, the lateral lobes obovate 2 mm long and wide; stamens slightly exserted beyond the mouth of the corolla tube; anthers unequal, posterior thecae 3.5 mm long, anterior thecae 6 mm long; ovary minutely punctate. Capsule not seen.

Aphelandra plowmanii is morphologically similar to *A. crispata* Leonard emend. Wasshausen from Amazonian Colombia and Ecuador. The new species is distinguished by having leaf margins entire or slightly undulate, bracts bright orange and recurving and corollas that are either white tinged with magenta on lower lip or tube carmin red, lower lip yellow with two dark-red spots at throat. In contrast, in *A. crispata* the lateral veins terminating in broad teeth 1–5 mm high and 2–2.5 cm apart, the bracts are red to purplish, crisped or twisted but not recurved and corollas are pinkish-purple to violet.

Distribution.—Along trails and in mature upland forest on well-drained alluvial soil, 130–ca 600 m elevation.

Material studied in addition to the type: **PERU. San Martín:** along road between Tocache Nuevo and Juanjui, ca. 96 km N of Tocache Nuevo, 84 km S of Juanjui, 14.1 km beyond bridge over Río Pulcache (and town of San Martín not Pulcache as on maps), ca. 600 m, 7°41'S, 76°40'W, 8 Apr 1984, *Croat 58000* (MO, US). Loreto: Prov. Maynas, Indiana, Explorama Inn, 3°30'S, 73°05'W, 108 m, 12 Apr 1992, *Vasquez, Grandez & Jaramillo 18217* (MO, US); ca. 2 km W of Indiana on Rio Amazonas, 3°30'S, 73°02'W, 130 m, 13 Feb 1987, *Gentry, Vasquez & Jaramillo 55808* (MO, US); Explorer's Inn near Indiana, 3°30'S, 73°3'W, 130 m, 14 Feb 1989, *Gentry, Vasquez & Jaramillo 65745* (MO, US).

Aphelandra knappii Wasshausen, sp. nov. (**Fig. 2A–H**). TYPE: PERU. SAN MARTÍN. Prov. Lamas: Convento, trail to Nuevo Lamas, km 68 of Tarapoto-Yurimaguas road, 6°16'S, 76°17'W, 200 m, 20 Aug 1986, *Sandra Knapp 8077* (HOLOTYPE: US; ISOTYPE: MO).

Herb or shrub 1–4 m tall; stems terete to subquadrangular, glabrous, drying dark-purplish. Leaves long-petiolate, the petioles 3–5 cm long, glabrous, drying dark-purplish, the blades broadly elliptic to ovate, 15–20 cm long, 6–10 cm wide, acuminate at apex, narrowed and attenuate at base, glabrous, thin, the veins (10–12 pairs) glabrous, conspicuous on both the upper and lower surface, the margin entire and slightly undulate. Inflorescence of 3–5 short, axillary and terminal spikes, these few-flowered and congested at the tips of the branches, the peduncles 3–4 cm long, glabrous, drying dark-purplish; bracts obovate, somewhat asymmetrical, 12–15 mm long and 8–10 mm wide, rather thin, glabrous, obtuse or rounded at apex, veination prominent, margin entire; bractlets oblong to lanceolate, 4 mm long and 1 mm wide, minutely ciliolate at tip; calyx 4–4.5 mm long, deeply lobed, lobes subequal, posterior lobe oblong, 4–4.5 mm long and 2 mm wide, truncate at apex, anterior pair lanceolate, 5 mm long and 1.5 mm wide, the lateral pair 5 mm long and 1 mm wide; corollas yellow with lobes apically green-tipped, 40 mm long, tube glabrous without and tomentose within at insertion of filaments base, the tube suberect, 36 mm long, 1 mm wide at base, this to 5 mm above base, then gradually enlarged to 7–9 mm at mouth, the lips spreading, the upper lip 5–6 mm long, the 2 lobes 4 mm long and 3 mm wide, rounded, the lower lip 3-lobed, the middle lobe 4 mm long, 3.5 mm wide, the lateral lobes 3.5 mm long and 3.5 mm wide; stamens exserted 8–10 mm beyond the mouth of corolla tube; filaments 40 mm long, tomentose at base; anther thecae 5 mm long, dorsally tomentose; pollen white; ovary 2 mm high; style 55 mm long, exserted. Capsule clavate, 15 mm long, 5 mm wide, blunt at tip, nitid, glabrous; seeds dark brown, flat, subcircular, 4 mm in diameter, sparingly papillose.

Aphelandra knappii is morphologically similar to *A. jacobinioides* Lindau also found in Ecuador and Peru. The new species is distinguished by having broadly elliptic to ovate, glabrous leaf blades, peduncles 3–4 cm long, glabrous, these drying dark-purplish, bracts obovate, somewhat asymmetrical, 12–15 mm long, obtuse or rounded at apex and corollas yellow, with lobes apically green-tipped, 40 mm long, tube 36 mm long and



FIG. 2. **A–F:** *Aphelandra knappii* (*Knapp 8077*). **A.** Habit. **B.** Bract. **C.** Bractlets and calyx lobes. **D.** Corolla and stamens. **E.** Corolla expanded showing attachment of filaments, anther thecae and ovary and pistil.

7–9 mm wide at mouth. In contrast, in *A. jacobinioides* the leaf blades are oblong-elliptic, the pubescent peduncles are 1–2 cm long,, not drying dark-purplish, the bracts are broadly ovate, symmetrical, 10 mm long, truncate and submucronate at apex and the corollas are orange to yellow, 48 mm long, the tube 42 mm long and 16 mm wide at mouth.

Distribution.—Tropical wet forest, red clay and white sand at elevations between 200–800 m.

Material studied in addition to the type: **PERU. San Martín:** Lamas, Convento, trail to Tioyacu and Nuevo Lamas, km 68 of Tarapoto-Yurimaguas road, 6°16'S, 76°17'W, ca. 270 m, 16 Jun 1984, *Knapp & Mallet 6522* (BH, US); Lamas, trail from Convento to Nuevo Lamas, km 68 Tarapoto-Yurimaguas, 6°16'S, 76°17'W, 200–800 m, 22 Mar 1986, *Knapp & Mallet 6896* (MO, US); Lamas, Convento trail to Tioyacu and Nuevo Lamas (then to Rio Shanusi), km 68 of Tarapoto-Yurimaguas road, 6°16'S, 76°17'W, ca. 200 m, 19 Apr 1986, *Knapp & Mallet 7105* (MO, US). **Loreto:** Balsapuerto, 220 m, Jan 1933, *Klug 2847* (US); Balsapuerto (lower Rio Huallaga basin), 150–350 m, 28–0 Aug 1929, *Killip & Smith 28617* (US).

Aphelandra davidsonii Wasshausen, sp. nov. (**Fig. 3A–H**). TYPE: PERU. HUANUCO: Cordillera Azul, ca. 38.2 km E of Tingo María on road to Pucallpa, 1730 m, 19 Nov 1979, *Christopher Davidson* and *Josephine Jones* 9276 (HOLOTYPE: US; ISOTYPE: LAM).

Low shrub ca. 1.3 m tall; stem terete to subquadrate, glabrous, drying brownish. Leaves long-petiolate, the petioles (unwinged portion) 1.5–2.5 cm long, glabrous to sparingly and inconspicuously puberulous, the blades elliptic to oblong, 10.5–15 cm long, 3.5–5 cm wide, glabrous, acuminate at apex, narrowed from above the middle and attenuate at base, firm, the veins (10–11 pairs) slightly raised and conspicuous both above and below, glabrous, secondary veins conspicuous on lower surface, margin entire. Inflorescence of 4–5 short, axillary and terminal spikes, these yellow, few-flowered and congested at the tip of branches, the peduncles 1.5–2 cm long, canaliculated, glabrous; bracts yellow, narrowly obovate, somewhat asymmetrical, 10–12 mm long and 7–8 mm wide, firm, glabrous, obscurely 2-lobed at apex, cuneate at base, margin entire; bractlets lanceolate to narrowly ovate, 3–3.5 mm long, 1–1.5 mm wide, striate-nerved, subhyaline, glabrous; calyx 5 mm long, lobes lanceolate, striate-nerved, subhyaline, glabrous, the posterior lobe 2 mm wide, the anterior pair 1 mm wide, the lateral pair 0.5 mm wide, both pairs mucronulate at apex; corolla yellow-green, 28 mm long, glabrous, the tube suberect, 25 mm long, 2 mm wide at base, 4 mm wide at mouth, the upper lip 3–4 mm long, the lobes 1 mm long and 2.5 mm wide, rounded, the lower lip 3-lobed, the middle lobe 3 mm long and 3 mm wide, the lateral lobes 3 mm long and 2 mm wide, all obtuse or rounded; stamens reaching the tip of the upper lip; filaments tomentose at point of insertion; anther thecae 2.5 mm long; ovary 3 mm high; style 28 mm long, exserted. Capsule not seen.

Aphelandra davidsonii is also morphologically similar to *A. jacobinioides* Lindau from Ecuador and Peru. This new species is distinguished by being a low shrub, ca. 1.3 m tall; stems glabrous, drying brownish; leaf blades smaller, 10.5–15 cm long and 3.5–5 cm wide, firm; bracts yellow, narrowly obovate, somewhat asymmetrical, obscurely 2-lobed at apex; bractlets glabrous at apex and corollas yellowish-green, 28 mm long, tube 25 mm long, 4 mm wide at mouth. In contrast, plants of *A. jacobinioides* are shrubs to 4 m tall; branches are puberulous, not drying brownish; leaf blades are 16–20 cm long, 6–8 cm wide, membranous; bracts greenish, broadly ovate, symmetrical, truncate and submucronate at apex; bractlets apically pilose and corollas orange to yellow, 48 mm long, tube 42 mm long, 16 mm wide at mouth.

Distribution.—Dense primary montane forest on steep NW slope at elevation between 1500 and 1800 m.

Material studied in addition to the type: **PERU. Huanuco:** Divisoria, between Tingo María and Boquerón, 1500–1800 m, Ferreyra 1675 (GH, US).

Aphelandra aucayacuensis Wasshausen, sp. nov. (**Fig. 4 A–F**). TYPE: PERU. HUANUCO. Prov. Leoncio Prado: Distrito Jose Crespo y Castillo, Quebrada de Sangapilla, near to Aucayacu, 600 m, 4 Mar 1978, *José Schunke V. 9992* (HOLOTYPE: MO; ISOTYPE: US).

Herb or shrub 0.3–1.3 m tall; stems terete to subquadrangular, glabrous, drying dark reddish-brown. Leaves long-petiolate, the petioles (unwinged portion) 1–3 cm long, glabrate to sparingly puberulous, the blades broadly elliptic to obovate, 11–20 cm long, 5–9 cm wide, acuminate at apex, narrowed and attenuate at base, glabrous, membranous, the primary veins (9–11 pairs) glabrous, conspicuous on both the upper and lower surface, the margin entire. Inflorescence of 3–8 short, axillary and terminal spikes, these few-flowered and congested at the tips of branches, the peduncles 1–3 cm long, dark reddish-brown; bracts green, lower broadly



FIG. 3. **A–H:** *Aphelandra davidsonii* (*Davidson & Jones 9276*). **A.** Habit. **B.** Bract. **C.** Bractlets and calyx lobes. **D.** Bractlets. **E.** Corolla and anther thecae. **F.** Corolla expanded showing attachment of filaments and anther thecae. **G.** Bractlets, calyx lobes and pistil. **H.** pistil and nectar disk.



FIG. 4. **A–F:** *Aphelandra aucayacuensis* (*Schunke V. 9992*). **A.** Habit. **B.** Lower bract. **C.** Upper bract. **D.** Bractlets. **E.** Bractlets, calyx lobes, style and ovary. **F.** Corolla and anther thecae. **G.** Corolla expanded showing attachment of filaments and anther thecae.

ovate, 12–15 mm long and 12–13 mm wide, apically somewhat asymmetrically bilobed, becoming narrower to ca. 10 mm wide toward apex, apically acute, all firm, glabrous, minutely gland-dotted, distinctly parallel nerved, margin entire; bractlets lanceolate, somewhat shorter than the calyx lobes, 4 mm long, 1.5 mm wide, striate-nerved, subhyaline, glabrous, minutely ciliolate at apex; calyx 4–5 mm long, the lobes lanceolate, striate-nerved, subhyaline, glabrous, the posterior lobe 1.5 mm wide, the anterior pair 1 mm wide, the lateral pair 0.5 mm wide, all minutely ciliolate at apex; corolla yellow, 30 mm long, glabrous, the tube suberect, 25 mm long, 4 mm wide at base, 7–8 mm wide at mouth, the upper lip erect or spreading, 5 mm long, the lobes 1 mm long and 2 mm wide, puberulous within, the lower lip 3-lobed, the middle lobe 4 mm wide, the lateral lobes 3 mm long and 3 mm wide, all obtuse or rounded; stamens reaching the tip of the upper lip; filaments tomentose at point of insertion; anther thecae 3 mm long. Capsule green, clavate, 12–13 mm long, 4 mm wide, blunt at tip, nitid, glabrous; seeds dark brown, flat, suborbicular, 4 mm in diameter, sparingly papillose.

Aphelandra ancayacensis is also morphologically similar to the more widespread species *A. jacobinioides* from Ecuador and Peru. It is distinguished from the later species by plants being somewhat smaller herbs or shrubs, 0.3–1.3 m tall; stems dark reddish-brown; leaf blades elliptic to obovate; peduncles dark reddish-brown, somewhat longer, 1–3 cm long; bracts green, 12–15 mm long and 10–13 mm wide, lower apically somewhat asymmetrically bilobed, upper apically acute, all minutely gland-dotted and corollas yellow, 30 mm long, tube 25 mm long, 7–8 mm wide at mouth. In contrast, *A. jacobinioides* are plants of shrubs to 4 m tall; stems not dark reddish-brown; leaf blades oblong-elliptic; peduncles not dark reddish-brown, shorter, 1–2 cm long; bracts green, 10 mm long, 9 mm wide, all uniform in shape and size, truncate and submucronate at apex, lacking glandular dots and corollas orange to yellow, 48 mm long, tube 42 mm long, 16 mm wide at mouth.

Distribution.—In well-drained soils, primary forest on the upper river terrace at elevations between 325 and 650 meters.

Material studied in addition to the type: **PERU. San Martín:** 23 km S of Nuevo San Martín (72 km S of Shumanza), 7°45'S, 76°35'W, 650 m, 16 Jul 1982, *Gentry, Smith & Tredwell 37590* (MO, US). **Huanuco:** Cerros Cucharas, 620 m, 5 Mar 1954, *Woytkowski 1146* (US). **Pasco:** Prov. Oxapampa, Palcazu valley, Cabeza de Mono, 5–6 km W of Iscosacin, 10°12'S, 75°14'W, 325 m, 14–15 Apr 1983, *D.N. Smith 3699* (MO, US).

Aphelandra schunkei Wasshausen, sp. nov. (**Fig. 5A–G**). TYPE: PERU. HUANUCO. Prov. Leoncio Prado: Distrito Rupa Rupa, E of Tingo María, near Cerro Quemado, 672–800 m, 27 Feb 1978, *José Schunke V. 9944* (HOLOTYPE: MO; ISOTYPE: US).

Herbs or shrubs 0.4–1.5 m tall; stems subquadrangular, glabrous. Leaves petiolate, the petioles 1.5–3 cm long, glabrate to puberulous, the trichomes sordid, the blades elliptic to broadly elliptic to oblong, 15–22(–26) cm long, 4–7(–9) cm wide, acuminate at apex, narrowed and attenuate at base, rather firm, glabrous, shining intensely olive-green, veination prominent on lower surface, the primary veins (14–18 pair) glabrous or puberulous, the trichomes appressed, the margin entire or slightly undulate. Inforescence of 2–10 short, axillary and terminal spikes, these few-flowered and congested at the tips of the branches, the peduncles 2–2.5 cm long, glabrous, canaliculated, bracts intensely green, narrowly obovate to ovate, 13–17(–24) mm long and 8–10(–14) mm wide, firm, glabrous glandular punctuate, striate-nerved, acuminate at apex, cuneate at base, margin entire; bractlets lanceolate, shorter than calyx lobes, 2.75–3 mm long, 1 mm wide, striate-nerved, subhyaline, glabrous, ciliolate at apex; calyx 4–5 mm long, the lobes lanceolate, striate-nerved, subhyaline, glabrous, the posterior lobe 1.5 mm wide, the anterior pair 1 mm wide, the lateral pair 0.5 mm wide, all minutely ciliolate at apex; corolla yellow to greenish yellow, 35–40 mm long, glabrous, the tube suberect, 30–35 mm long, 4 mm wide at base, 7–9 mm wide at mouth, the upper lip erect or spreading, 5–7 mm long, the lobes 3 mm long and 3.5 mm wide, puberulous within, the lower lip 3-lobed, the middle lobe 3.5–4 mm in diameter, the lateral lobes 3 mm long and 3.5 mm wide, all obtuse or rounded; stamens reaching the tip of the upper lip; filaments tomentose at point of insertion; anther thecae 4 mm long, dorsally tomentose; ovary 3 mm high, glabrous; style 30–35 mm long, slightly exceeding the anther thecae. Capsule green, clavate, 13 mm long, 4 mm wide, blunt at tip, nitid, glabrous; seeds dark brown, flat, suborbicular, 4 mm in diameter, sparingly papillose.

Aphelandra schunkei is morphologically similar to *A. davidsonii* Wasshausen also found in the Department of Huanuco, Peru. This new species is distinguished by having larger leaf blades, 15–22(–26) cm long and 4–7(–9) cm wide; green spikes on longer peduncles 2–2.5 cm long; bracts intensely green, 13–17(–24) mm long

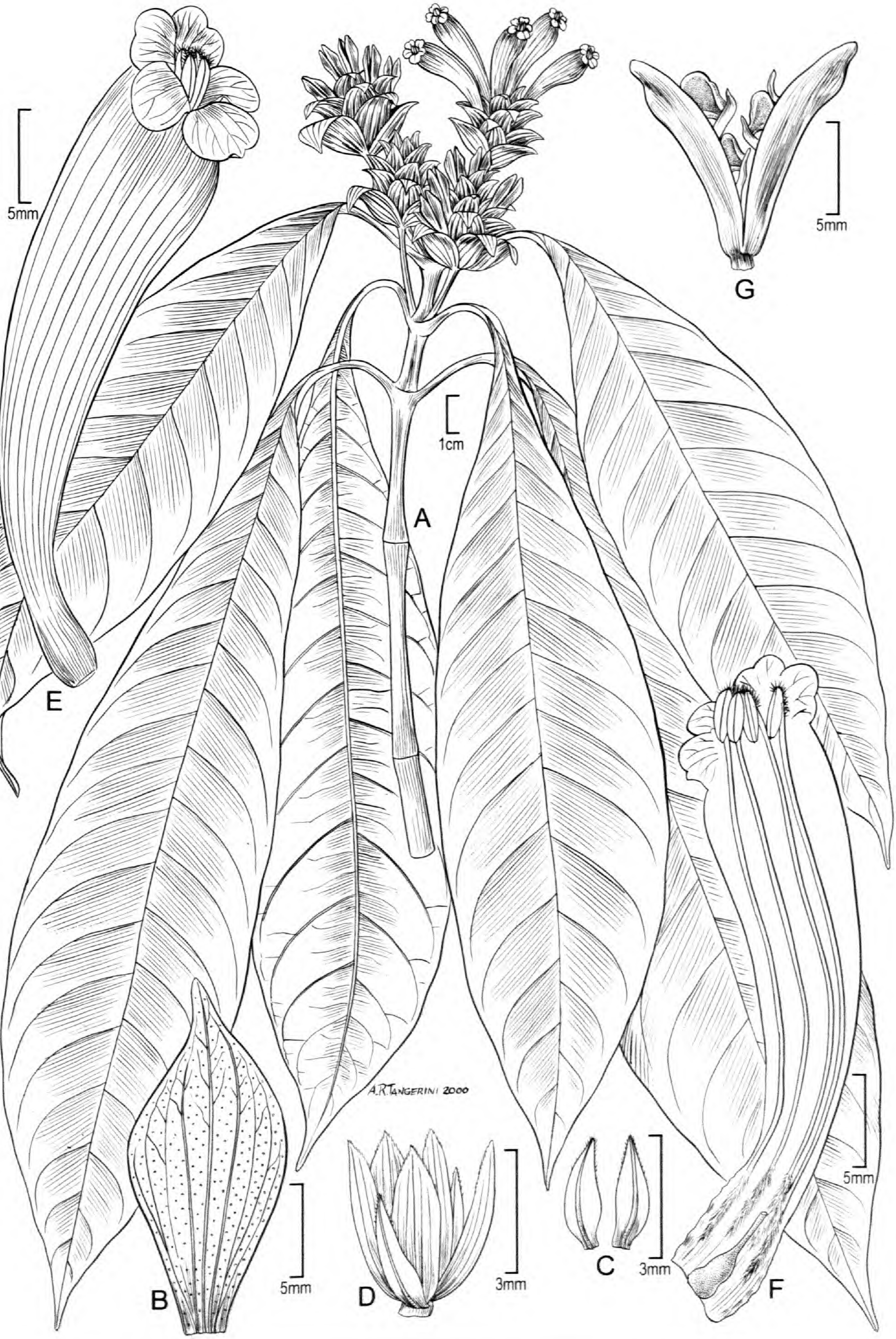


FIG. 5. **A–G:** *Aphelandra schunkei* (*Schunke V. 9944*). **A.** Habit. **B.** Bract. **C.** Bractlets. **D.** Bractlets and calyx lobes. **E.** Corolla. **F.** Corolla expanded showing attachment of filaments and anther thecae. **G.** Capsule, retinacula and seeds.

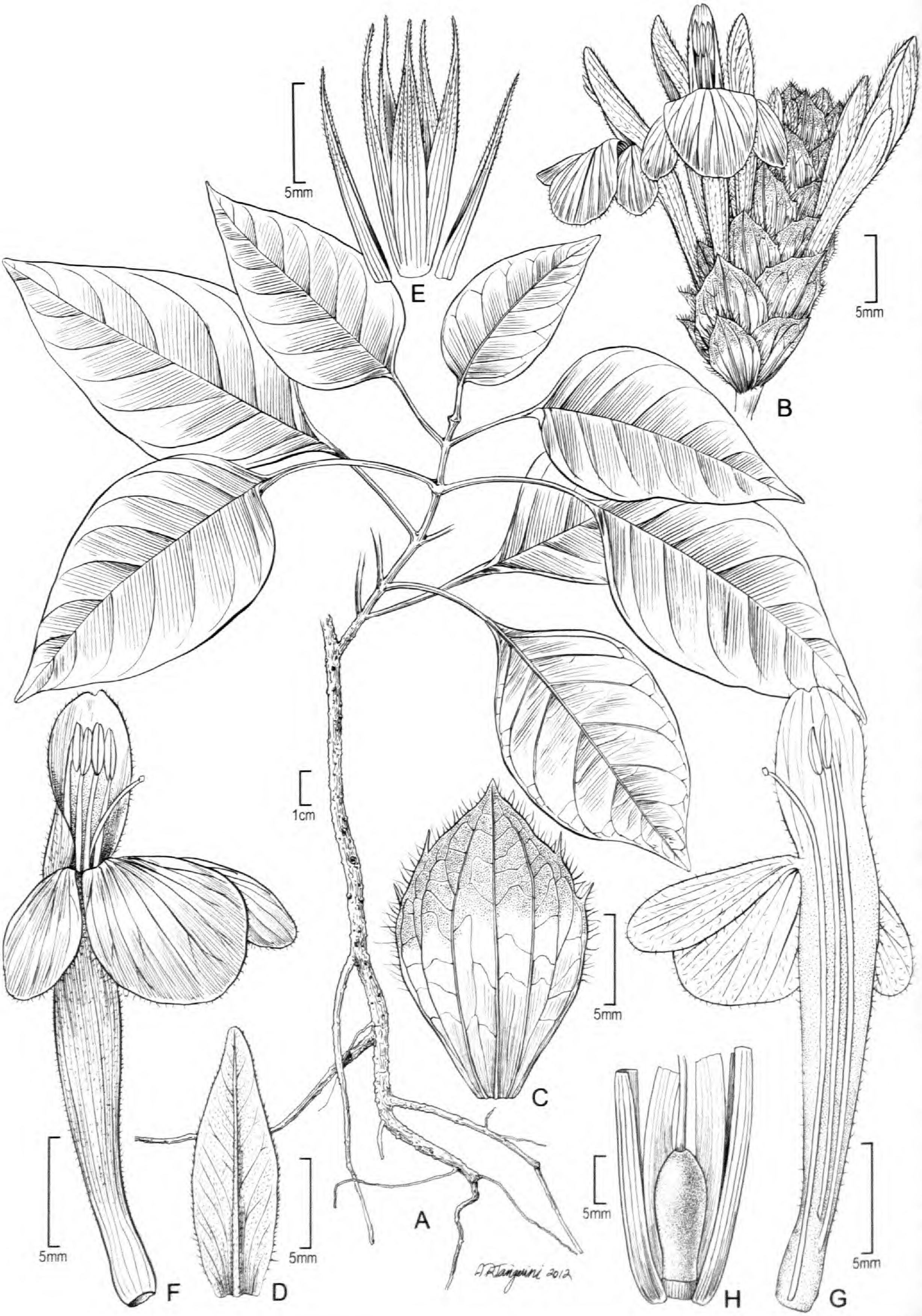


FIG. 6. **A–H:** *Aphelandra espinosae* (*Klitgaard et al. 532*). **A.** Habit. **B.** Spike and corollas. **C.** Bract. **D.** Bractlets. **E.** Bractlets and calyx lobes. **F.** Corolla, stamens and pistil. **G.** Corolla expanded showing 2 of the 4 stamens and attachment of filaments and pistil. **H.** Ovary, nectar disk and base of calyx lobes.

and 8–10(–14) mm wide, acuminate at apex and corollas somewhat longer, 35–40 mm long, the tube 30–35 mm long and 7–9 mm wide at mouth. In contrast, in *A. davidsonii* the leaf blades are 10.5–15 cm long, 3.5–5 cm wide; the spikes are yellow, the peduncles 1.5–2 cm long; bracts yellow, 10–12 mm long and 7–8 mm wide, obscurely 2-lobed at apex and the corollas 28 mm long, the tube 25 mm long and 4 mm wide at mouth.

Distribution.—Primary and secondary wet forest at elevations between 350–900 m.

Material studied in addition to the type: **PERU: San Martín:** Mariscal Caceres, Dtto. Tocache Nuevo, estuary of the Río Mishollo (right margin of Río Huallaga), 7 Mar 1971, *Schunke V. 4751* (US); Quebrada Luis Salas (5 km NE of Puerto Pizana, 350–370 m, 3 Aug 1973, *Schunke 6657* (US); road to Shunte, (E of the Palo Blanco bridge), 500–800 m, 14 Jul 1974, *Schunke V. 7387* (US); Prov. Mariscal Caceres, Madre Mia, 760–880 m, 15 Mar 1977, *Boeke & Ramirez 1274* (US). **Huanuco:** Prov. Huanuco, Tingo María, 5 Jul 1940, *Asplund 12272* (S); Prov. Leoncio Prado, Río Pacayaco, Pacayaco bridge, 570 m, 30 Mar 1976, *Plowman & Kennedy 5774* (US); Prov. Leoncio Prado, Dtto. Rupa Rupa, E of Tingo María, on edge of the quebrada, 700 m, 20 Nov 1971, *Schunke V. 5172* (US); E of Tingo María, near Cerro Quemado, 672–800 m, 22 Feb 1978, *Schunke V. 9946* (US); Prov. Leoncia Prado, Dtto. Daniel Alomias Robles, W of Restaurant Canabraba, around Delicios, 800–900 m, 18 Jun 1976, *Schunke V. 9316* (US). **Pasco:** Prov. Oxapampa, W side of Cordillera San Matias, between Iscosacin and summit, 10°11'S, 75°12'W, 680–850 m, 22 Jun 1982, *D. Smith 2037* (MO, US).

Aphelandra espinosae Wassshausen, sp. nov. (**Fig. 6A–H**). TYPE: ECUADOR. LOJA: Hda. Banderones, which is 2 hours walk from 5 km road Limo-Casaderos, 80°10'15'W, 03°58'660'S, 1000 m, 9 May 1997, *B.B. Klitgaard, P. Lozano, T. Delgado, N. Aguirre, H. Aleyandro & R. Tapia 532* (HOLOTYPE: US; ISOTYPE: LOJA).

Herb to 0.5 m tall; stem subquadrangular, woody, glabrous, covered with warty protuberances. Leaves long-petiolate, the petioles (unwinged portion) 2–2.5 cm long, canaliculated, glabrous, the blades oblong to ovate, 10–11.5 cm long, 4–5.5 cm wide, glabrous, acuminate at apex, narrowed and conspicuously long-attenuate at base, membranous, the upper surface dark-olive, the lower surface pale-olive, the lateral veins rather inconspicuous, more prominent beneath than above, the margin entire or slightly undulate. Inflorescence of 1–3 short, axillary and terminal spikes, these few-flowered, 4.5 cm long and 2 cm wide (without spreading corollas), congested at tips of the branches, peduncles lacking; bracts densely imbricate, pale yellow with green venation and green apices, ovate, 15–16 mm long and 10–11 mm wide, somewhat asymmetrical, glabrous, acute to acuminate at apex, the tip minutely apiculate, cuneate at base, 3–5-nerved, margin provided with 2 pairs of minute dents, ciliolate; bractlets linear, subcarinate, 10 mm long, 1.5 mm wide, aristate, striate nerved, subhyaline, glabrous; calyx lobes linear, 12 mm long, aristate, striate-nerved, subhyaline, glabrous, the posterior lobe 2.5 mm wide, the anterior pair 2 mm wide and the lateral pair 1.5 mm wide; corolla orange, 50–55 mm long, sparingly puberulous, the tube erect, 2 mm wide at base, slightly narrowed at 5 mm above base, thence gradually expanded to 8 mm wide at mouth, the upper lip erect, narrowly ovate, 16 mm long, 11 mm wide, retuse at apex, the lower lip spreading, 3-lobed, the middle lobe ovate, 16 mm long, 11 mm wide, obtuse to rounded and sparingly pilose at apex, the lateral lobes narrowly ovate, 12 mm long, 7 mm wide, obtuse or rounded at apex; stamens exserted 10 mm beyond the mouth of the corolla tube; anther thecae 4 mm long; ovary 4 mm long, 2 mm wide, glabrous. Capsules not seen.

Aphelandra espinosae is morphologically similar to *A. guayasii* Wasshausen also from Ecuador. The new species is distinguished by being herbaceous, 0.5 m tall, having sessile spikes, glabrous bracts with margins denticulate and corollas orange, 50–55 mm long, sparingly puberulous. In contrast, plants in *A. guayasii* are suffrutescent, to 0.75 m tall, and have pedunculate spikes densely white-glandular pilose, and entire bracts and corollas straw-colored, 55–65 mm long and sparingly pilose to glandular-pilose.

Distribution.—This species is known only from the type locality.

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ESTUDIOS EN LAS APOCYNACEAE NEOTROPICALES XLIII: SINOPSIS DEL GÉNERO *ALLOMARKGRAFIA* (APOCYNACEAE: APOCYNOIDEAE) EN COLOMBIA

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RESUMEN

Se presenta una sinopsis del género *Allomarkgrafia* (Apocynaceae, Apocynoideae) en Colombia. Se reconocen 5 especies, incluyendo la descripción de **A. antioquiana.** Se brinda una clave para los taxones, datos taxonómicos, especimenes representativos examinados y mapas de distribución para cada especie.

PALABRAS CLAVE: Apocynaceae, Apocynoideae, Mesechiteae, *Allomarkgrafia*, Colombia

ABSTRACT

A synopsis of the genus *Allomarkgrafia* in Colombia (Apocynaceae: Apocynoideae) is presented. Five species are recognized, including the description of a new species, **A. antioquiana.** A key for the taxa, taxonomical data, selected examined specimens, and distribution maps for every species are included.

KEY WORDS: Apocynaceae, Apocynoideae, Mesechiteae, *Allomarkgrafia*, Colombia

Allomarkgrafia (Apocynaceae) es un género de 10 especies, distribuidas desde el S de Honduras a Perú (Morales 1997, 2009), el cual pertenece a la subfamilia Apocynoideae, tribu Mesechiteae (Endress et al. 2007). Dentro de este grupo, *Allomarkgrafia* se encuentra cercanamente relacionado con *Mesechites* (e.g., Simões et al. 2004) y ambos géneros se pueden separar del resto por sus inflorescencias cimosas y hojas sin domacios en la superficie abaxial. *Allomarkgrafia* se separa de *Mesechites* por la presencia de cinco crestas infraestaminales que se extienden desde la base de los filamentos hasta la base del tubo de la corola. Adicionalmente, en *Allomarkgrafia* el indumento infraestaminal es conspicuo y se extiende desde los filamentos hasta más o menos la parte medial del tubo (sobre las crestas), mientras que en *Mesechites*, el indumento está restringido a los filamentos (Fig. 1). Un carácter morfológico adicional que puede ayudar a separar especimenes estériles de ambos géneros es el hecho de que las venas terciarias en *Allomarkgrafia* se encuentran dispuestas en forma más o menos perpendicular al nervio central, mientras que en *Mesechites* la disposición es irregular y sin un patrón definido. Adiconalmente, en el primer género las venas son más conspicuas y están dispuestas en forma más aglomerada que en *Mesechites* (Fig. 2). Otro carácter tradicionalmente utilizado ha sido la forma de la corola (infundibuliforme en *Allomarkgrafia* e hipocrateriforme en *Mesechites*); sin embargo, con la descripción de *A. ecuatoriana* (Morales 1997) se demostró que corolas hipocrateriformes también estan presentes en Allomarkgrafia. Algunos estudios filogenéticos recientes (e.g., Simões et al. 2004), han sugerido una cercana relación entre ambos géneros. Tomando en cuenta que la alta variabilidad de la forma de la corola en géneros de la misma tribu (como *Mandevilla*), es probable que *Allomarkgrafia* deba ser reducido a la sinonimia de *Mesechites* es un futuro cercano. Sin embargo, por el momento y en espera de mayor evidencia molecular que apoye esta propuesta, mantendremos ambos grupos separados.

Basado en los registros de colecciones de más de 115 herbarios, se puede afirmar que en general, *Allomarkgrafia* es un género pobremente recolectado: de las 10 especies conocidas, apenas de *A. plumeriiflora* ha sido recolectada extensamente (más de 60 especímenes conocidos), mientras que tres taxones se conocen por entre

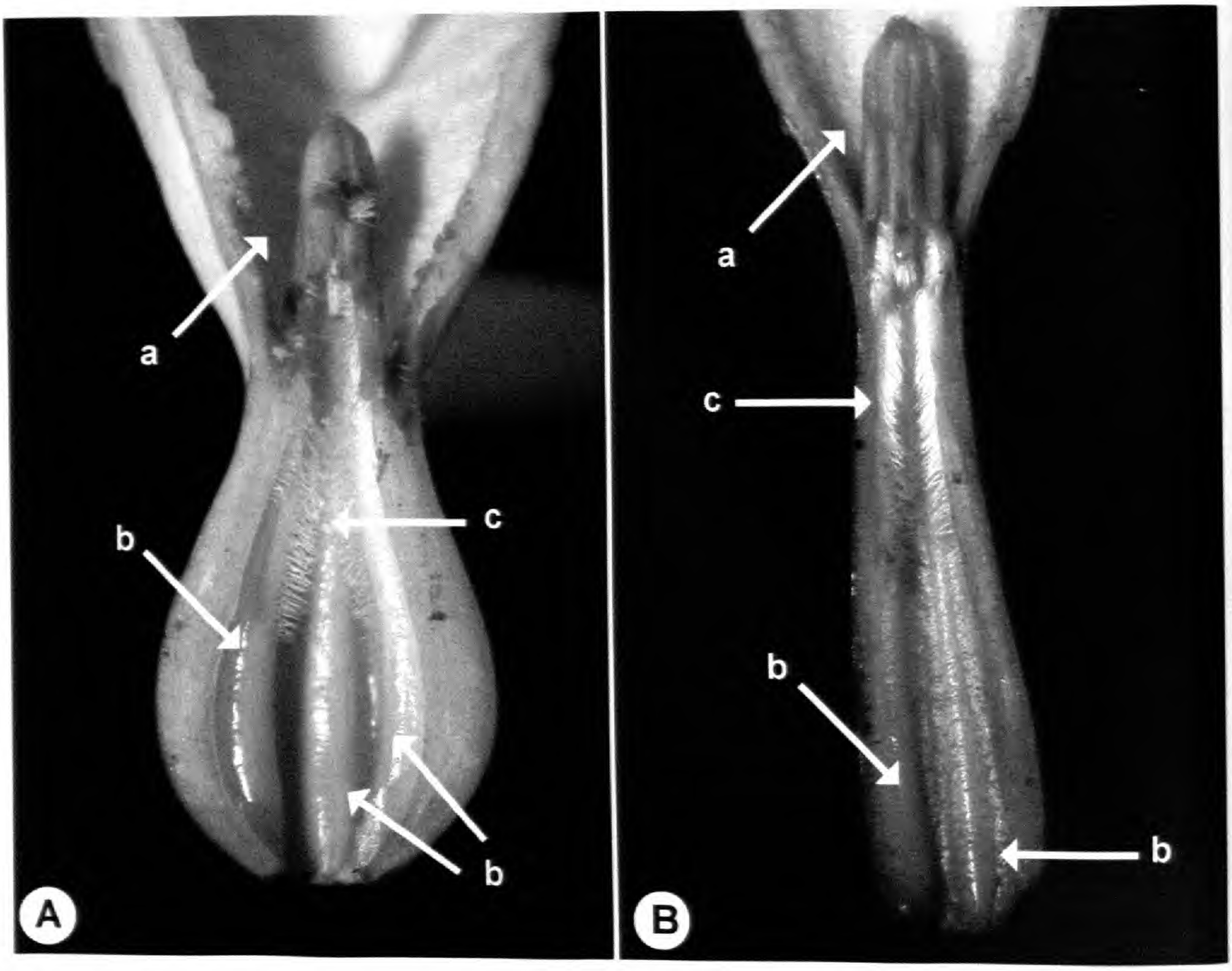


Fig. 1. Crestas infraestaminales en *Allomarkgrafia*. **A.** *A. plumeriifolia* (*J.F. Morales 19000*, INB). **B.** *A. brenesiana* (*J.F. Morales 18936*, INB). a. Anteras. b. Crestas infraestaminales. c. indumento infraestaminal.

13 y 26 colecciones [*A. brenesiana* Woodson, *A. campanulata* (Markgr.) J.F. Morales, *A. ovalis* (Markgr.) Woodson] y de las cinco restantes, 4 son endémicas y conocidas por menos de cuatro colecciones (Cuadro 1). Las especies son morfológicamente muy similares (en la forma y tamaño de las hojas o folículos y semillas) y son necesarias flores para poder proceder con una identificación apropiada.

Como parte del proceso de elaboración de un tratamiento de Apocynaceae sensu stricto (subfamilias Apocynoideae y Rauvolfioideae) para la serie Flora de Colombia, se presenta una sinopsis del género en este país. Para facilitar el entendimiento de la clave, las partes florales de la corola se ilustran en la Figura 3.

CLAVE PARA LAS ESPECIES DE *ALLOMARKGRAFIA* EN COLOMBIA

1. Parte inferior del tubo de la corola 39–42 mm de largo, la parte superior 4–5 mm de largo, la corola pareciendo hipocrateriform _____ **A. ecuatoriana**
1. Parte inferior del tubo de la corola 8–19 mm de largo, la parte superior 6–25 mm de largo, la corola típicamente infundibuliforme.
2. Brácteas 1,7–3 mm de largo, conspicuas y numerosas en la inflorescencia; flores generalmente aglomeradas; lóbulos de la corola 11–33 mm de largo.
3. Tubo de la corola conspicuamente inflado en la base; 14–25 mm de largo, lóbulos 11–21 mm de largo _____ **A. plumeriiflora**
3. Tubo de la corola no inflado en la base; 35,5–41 mm de largo, lóbulos 28–33 mm de largo _____ **A. antioquiana**
2. Brácteas hasta 1,1 mm de largo, inconspicuas y escasas en la inflorescencia; flores laxamente distribuidas; lóbulos de la corola 5–9 mm de largo.
4. Parte inferior del tubo de la corola 17–19 mm largo, la parte superior 19–22 mm largo _____ **A. foreroi**
4. Parte inferior del tubo de la corola 11–13 mm largo, la parte superior 10–13 mm largo _____ **A. laxiflora**

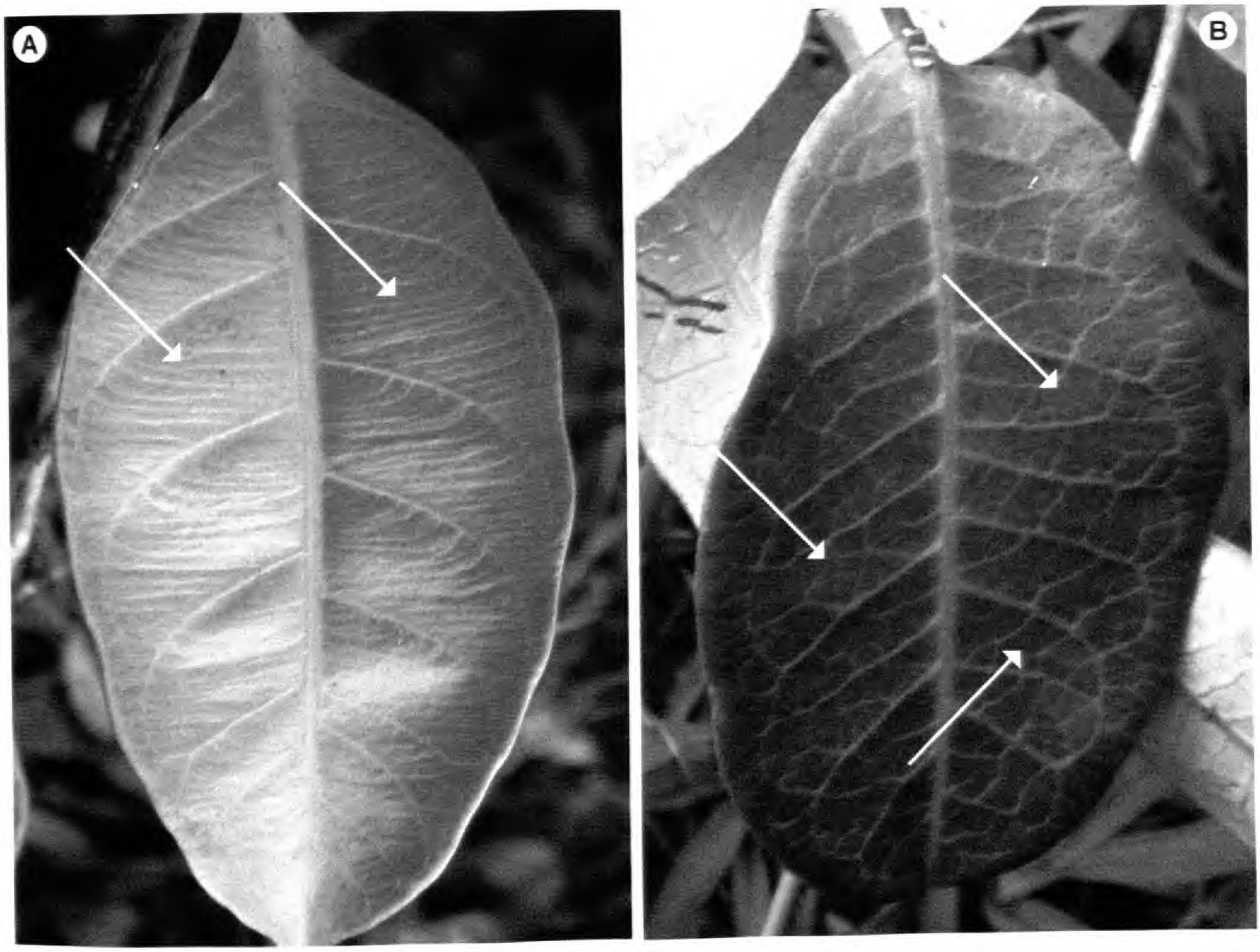


Fig. 2. Venas terciarias en *Allomarkgrafia* y *Mesechites* (señaladas con flechas). **A.** *A. plumeriifolia* (*Morales 19000*, INB). **B.** *Mesechites mansoanus* (*Morales 19966*, INB).

Allomarkgrafia antioquiana J.F. Morales, sp. nov. (**Figs. 4, 5**). Tipo. COLOMBIA. Antioquia: Municipio de San Luis, Vereda Manizales, orillas del Río Dormilón, 12 oct 1981 (fl), *C. Orozco, J. Rivera, J. Torres, G. Lozano & P. Pinto 611* (holotipo: MEDEL; isotipos: COL [fotografía, INB], INB).

A *Allomarkgrafia plumeriifolia* Woodson cui similis, corollae tubo 35,5–41 mm longis (vs. 14–25 mm) et corollae lobis 28–33 mm longis (vs. 11–21 mm) differt.

Liana; ramitas levemente aplanadas antes de los nudos en ramitas jóvenes, cilíndricas a subcilíndricas con la edad, glabras; coléteres interpeciolares inconspicuos, hasta 0,9 mm de largo. Hojas: pecíolos 15–18 mm de largo; láminas 12–19,2 × 3,4–5,5 cm, elípticas, el ápice cortamente acuminado, la base cuneada a obtusa, glabras, no revolutas, venación secundaria apenas impresa en ambas caras, las venas terciarias inconspicuas o no impresas, estas últimas cuando evidentes dispuestas en forma perpendicular en relación al nervio central, los coléteres agrupados en la base adaxial del nervio central en grupos de más de 10. Inflorescencia axilar, glabra, con numerosas flores, el raquis de color verde-púrpura, pedúnculo 21–26 mm de largo, pedicelos 12–15 mm de largo, brácteas 1,7–3 × 1,3–2 mm, angostamente ovadas, escariosas; sépalos 3,3–4,6 × 2–2,5 mm, angostamente ovados, el ápice agudo a obtuso, glabros, pero irregularmente ciliolados marginalmente, los coléteres distribuidos en hileras irregulares alrededor del ovario; corola blanca, glabra externamente, el tubo recto, la parte inferior 14,5–16 × 2–3,7 mm, la superior 21–25 mm de largo, cónica, con un diámetro de 14–17 mm en el orificio; lóbulos 28–33 × 20–25 mm, angostamente obovados; anteras 6,3–7 mm de largo, glabras dorsalmente, la base auriculada, con las aurículas obtusas o truncadas, cabeza estigmática 3,2–3,6 mm de largo, con cinco crestas basales; ovario 3,2–3,6 mm de largo, glabro; nectario profundamente pentalobulado, ligeramente más corto que el ovario. Folículos desconocidos.

Cuadro 1. Número de colecciones y distribución de las especies de *Allomarkgrafia*.

Especie	Distribución	Número de especímenes conocidos
Allomarkgrafia antioquiana J.F. Morales	Colombia	1
Allomarkgrafia brenesiana Woodson	Costa Rica y O de Panamá	23
Allomarkgrafia campanulata (Markgr.) J.F. Morales	Panamá	16
Allomarkgrafia ecuatoriana J.F. Morales	Colombia y Ecuador	3
Allomarkgrafia foreroi A.H. Gentry	Colombia y Ecuador	4
Allomarkgrafia insignis J.F. Morales	Costa Rica	1
Allomarkgrafia laxiflora A.H. Gentry	Colombia y Ecuador	3
Allomarkgrafia ovalis (Markgr.) Woodson	Ecuador y Perú	13
Allomarkgrafia plumeriiflora Woodson	Honduras a Colombia	65
Allomarkgrafia tubiflora Woodson ex Dwyer	Perú	8

Fuente: Morales 1997; Morales en prep.

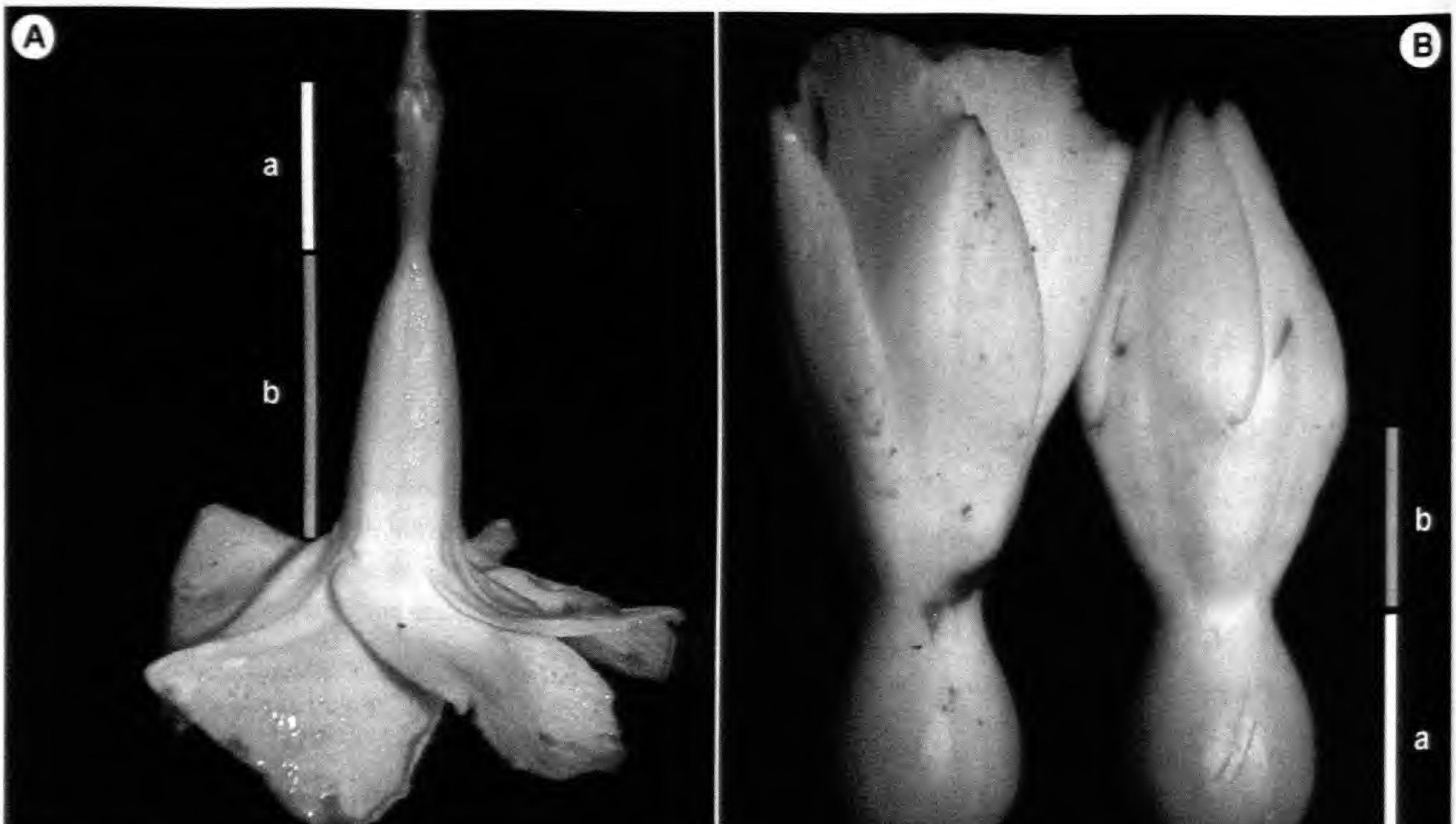


Fig. 3. Partes de la corola en corolas de *Allomarkgrafia*. **A.** *A. brenesiana* (*J.F. Morales 18936*, INB). **B.** *A. plumeriifolia* (*J.F. Morales 19000*, INB). a. Parte inferior del tubo. b. Parte superior del tubo.

Etimología.—El nombre de esta especie hace referencia al Departamento de Antioquia en Colombia.

Distribución.—Conocida por el momento únicamente de la localidad tipo, a 1400 m de elevación.

Allomarkgrafia antioquiana se puede confundir con facilidad con *A. plumeriiflora*, ya que ambas se caracterizan por sus inflorescencias con las flores aglomeradas y brácteas numerosas y conspicuas, pero se separa por sus flores mucho más grandes. El epíteto de esta especie está dedicado al Departamento de Antioquia.

Allomarkgrafia ecuatoriana J.F. Morales, Brittonia 49:340, f. 1. 1997. (**Fig. 5**). Tipo. ECUADOR. Carchi: Tulcan Cantón, parroquia Chical, Sector Gualpi medio, Reserva Indígena Awá, sendero a San Narcos al norte de la casa comunal, 23–27 may 1992 (fl), *Tipaz et al. 1150* (holotipo: INB; isotipos: MO [2 cartulinas], QCNE).

Distribución.—S de Colombia y Ecuador; en el país en elevaciones entre 200–300 m.

Allomarkgrafia ecuatoriana se puede reconocer por sus corolas pareciendo hipocrateriformes, con la parte

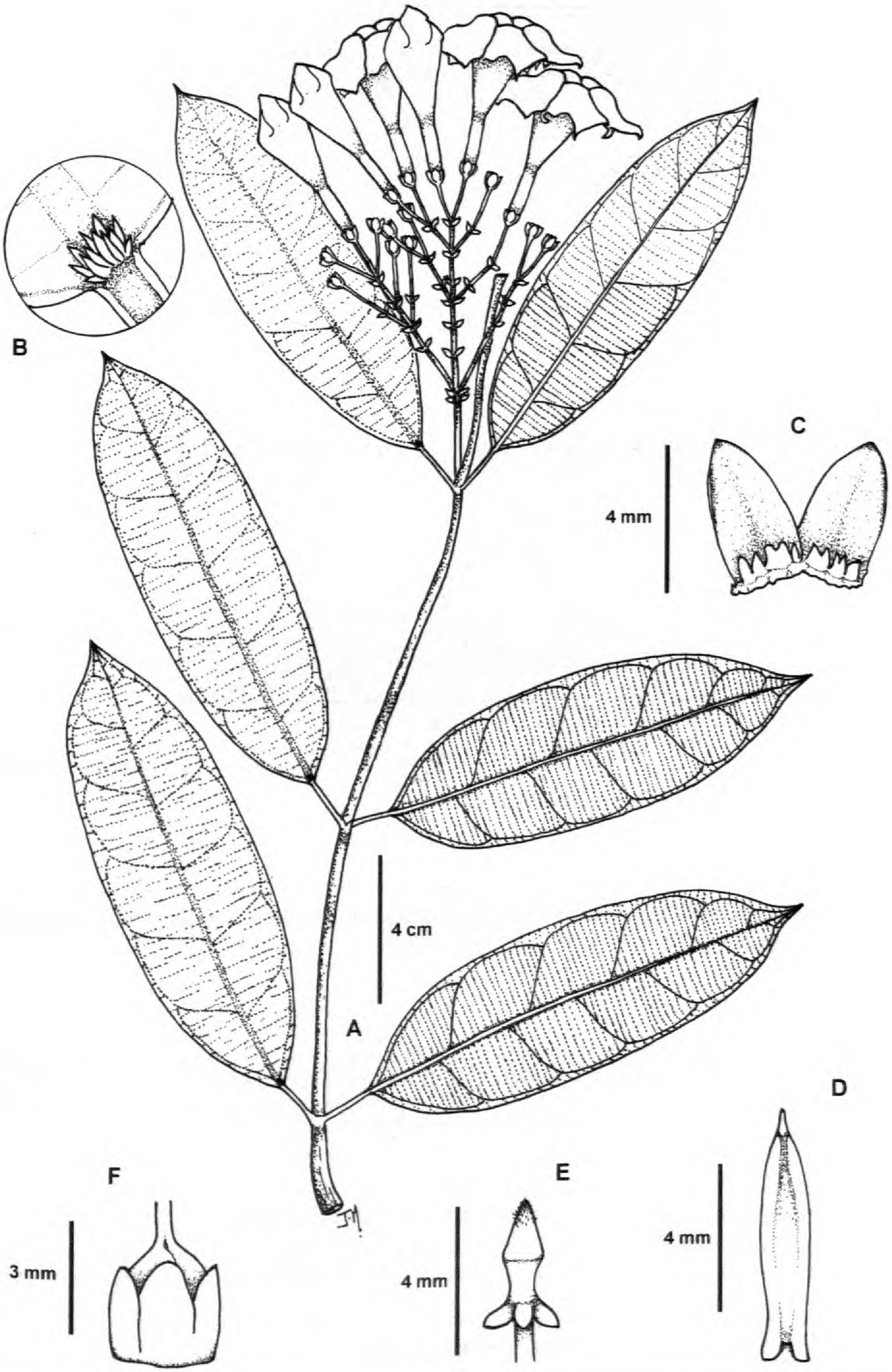


Fig. 4. *Allomarkgafia antioquiana* (*Orozco et al. 611*, A–B, COL; C–F, INB). **A.** Ramita con inflorescencia. **B.** Detalle de la superficie adaxial de la hoja, mostrando los coléteres agrupados en la base del nervio central. **C.** Vista adaxial de dos sépalos, mostrando los coléteres en la base. **D.** Antera, vista dorsal. **E.** Cabeza estigmática. **F.** Nectarios y ovario.



Fig. 5. Mapa de distribución de especies de *Allomarkgrafia* en Colombia.

superior del tubo muy corta y con la parte inferior del tubo muy larga, usualmente de más de 39 mm de largo. Esta especie originalmente era endémica a Ecuador (Morales 1997), pero fue reportada recientemente para Colombia (Morales 2006).

Especimenes representativos examinados: **Chocó:** región del río Baudo, 2 feb 1967 (fl), *Fuchs et al. 21716* (COL, INB, K, P, S, U, US). **Nariño:** Barbacoas, resguardo de El Sábalo, río Sábalo, 20 ago 1995 (fl), *González et al. 936* (PSO, QCA).

Allomarkgrafia foreroi A.H. Gentry, Phytologia 47:97. 1980. (**Fig. 5**). Tipo. COLOMBIA. Chocó: carretera Tutunendo-El Carmen, 26 abr 1979 (fl), *Forero et al. 5854* (holotipo: COL; isotipos: HUA, INB, MA, MO).

Distribución.—Colombia y Ecuador; en el país en elevaciones entre 150–350 m.

Allomarkgrafia foreroi se puede reconocer por sus inflorescencias con las flores laxamente dospuestas, con las brácteas hasta 1 mm de largo y las corolas con la parte inferior del tubo de 17–99 mm de largo. A pesar de ser reportada también en Ecuador, apenas se conocen 4 colecciones de esta especie (incluyendo el tipo).

Especimenes representativos examinados: **Antioquia:** Mutatá, camino hacia Pavarando Grande, 27 mar 1987 (fl), *Zarucchi et al. 5083* (HUA, MO, USF). **Meta:** Parque Nacional Natural Tinigua, Serranía Chamusa, feb 1994 (fl), *Stevenson 941* (COL [fotografía, INB], COAH)

Allomarkgrafia laxiflora A.H. Gentry, Ann. Missouri Bot. Gard. 76:923, f. 1. 1989. (**Fig. 5**). Tipo. COLOMBIA. Nariño: carretera Tumaco-Tuquerres, 25 nov 1981 (fl, fr), *Gentry et al. 34939* (holotipo: COL; isotipos: COL, MO, TULV [2 cartulinas]).

Distribución.—Colombia y Ecuador; en el país entre 100 y 900 m de elevación.

Por la forma de la corola, este taxa se podría confundir con *A. plumeriiflora*, ya que tienen ambas especies tienen corolas similares, pero *A. laxiflora* se puede separar por sus inflorescencias con las flores laxamente dispuestas y brácteas más pequeñas y escasas.

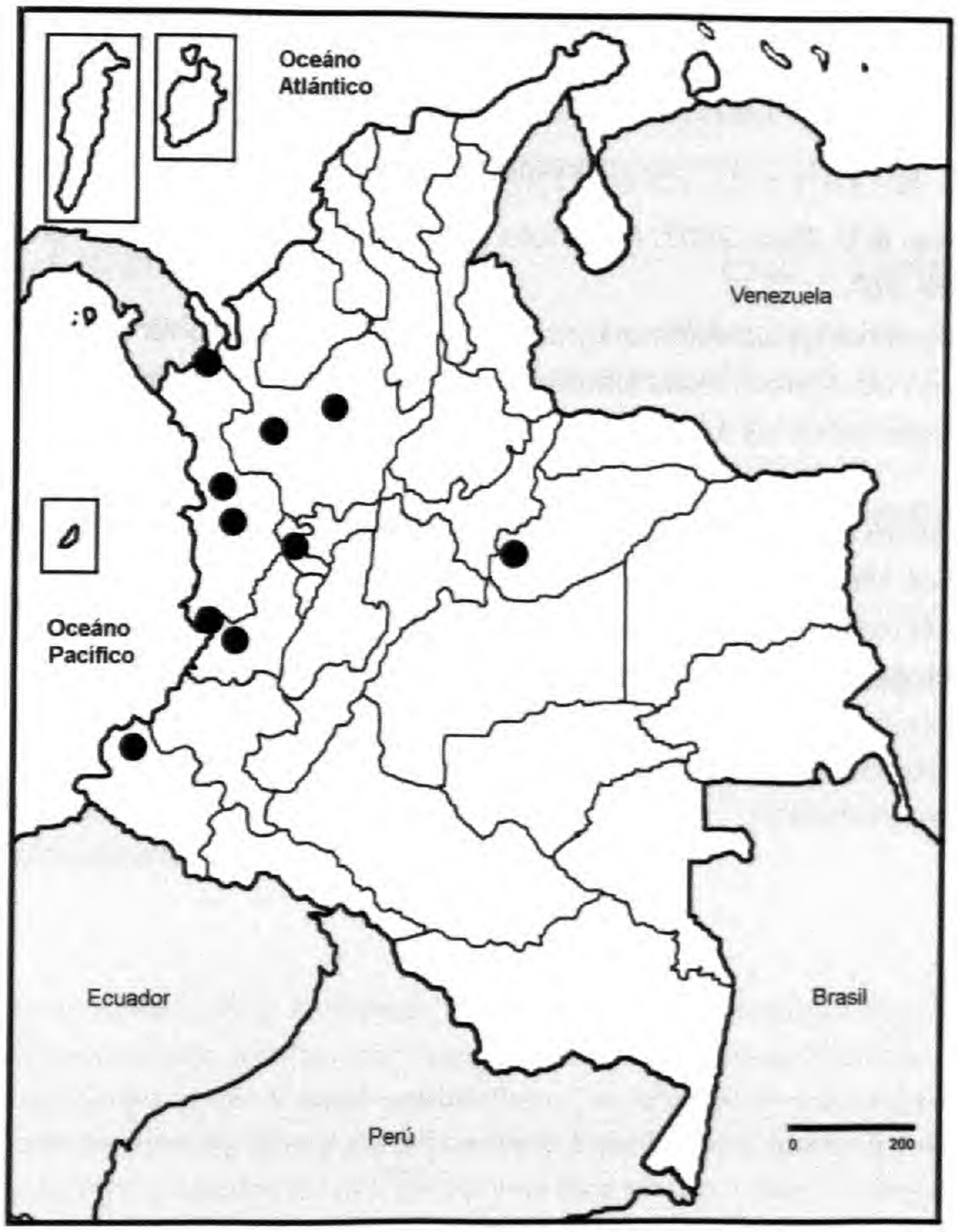


Fig. 6. Mapa de distribución de *Allomarkgrafia plumeriifolia* en Colombia.

Especímenes representativos examinados. **Valle del Cauca:** Buenaventura, Córdoba, San Cipriano, Reserva Natural del río Escalerete, 12 abr 1993 (fl, fr), *Devia et al. 3937* (COL, MO, TULV).

Allomarkgrafia plumeriiflora Woodson, Ann. Missouri Bot. Gard. 20:627. 933. (**Fig. 6**). Tipo. COLOMBIA. Boyacá: El Umbo, 13 oct 1932 (fl), *Lawrance 534* (holotipo: MO [fotografía, INB]; isotipos: ARIZ, F, G [3 cartulinas], GH, K, MO [fotografía, INB], NY, U, US).

Allomarkgrafia subtubulosa Woodson, Ann. Missouri Bot. Gard. 24:16. 1937. Tipo. COSTA RICA. Alajuela: San Ramón, 21 abr 1927 (fl), *Brenes 5457* (holotipo: F; isotipos: CR, GH, MO [fotografía, INB], NY).

Distribución.—S de Honduras a Costa Rica; en Colombia en elevaciones de 100–1200 m.

Allomarkgrafia plumeriiflora se puede distinguir por sus inflorescencias conspicuamente brácteadas, así como por el tamaño de la corola. Se puede confundir con *A. antioquiana*, pero esta última especie tiene flores más grandes y de forma diferente.

Especímenes representativos examinados. **Antioquia:** Frontino, parque nacional Las Orquídeas, 5 feb 1995 (fl), *Pipoly et al.* 18501 (JAUM, MO, NY). **Chocó:** 50 km al O de Las Animas, 4 km al E del río Pato, 11 ene 1979 (fl), *Gentry & Renteria 23972* (COL, HUA, MO). **Nariño:** Tumaco, Chaja, jun 1951 (fl, fr), *Romero-Castaneda 2720* (COL). **Risaralda:** Mistrato, entre Puerto de Oro y Jeguadas, 19 sep 1991 (fl), *Betancur et al. 2799* (COL). **Valle del Cauca:** Yatacué, Alto Anhicaya, valle del río Dagua, 17 jul 1984 (fl), *Gentry & Monsalve 48251* (COL, CUCV, JAUM, MEXU, MO).

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AULONEMIA DAVID-SMITHII AND *A. RUBRALIGULATA* (POACEAE: BAMBUSOIDEAE: BAMBUSEAE: ARTHROSTYLIDIINAE): TWO NEW SMALL-FLOWERED SPECIES FROM PERU

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ABSTRACT

Two new species of bamboo (Poaceae: Bambusoideae: Bambuseae: Arthrostylidiinae) are described from Peru. **Aulonemia rubraligulata** (Amazonas, Cajamarca, and Junín) has elongate, reddish inner ligules 20–45 mm long, foliage leaf blades 15–25 cm long and 0.7–2.3 cm wide, and pectinate-fimbriate sheath margins, while **A. david-smithii** (Pasco) has inconspicuous inner ligules, foliage leaf blades 25–38 cm long and 2.7–3.6 cm wide, the sheath margins with densely matted confluent fimbriae (these ultimately splitting) and terminal sheath fimbriae 10–15 mm long. A table is presented comparing the new species with their putative relatives *Aulonemia humillima* and *A. parviflora*. Scanning electron micrographs (SEMs) of the abaxial (lower) foliage leaf blade epidermis of both species are included, as is a key to the small-flowered Andean species of *Aulonemia*.

RESUMEN

Se describen dos nuevas especies de bambú (Poaceae: Bambusoideae: Bambuseae: Arthrostylidiinae) de Perú. **Aulonemia rubraligulata** (Amazonas, Cajamarca y Junín) tiene lígulas interiores alargadas, rojizas 20–45 mm de largo, hojas de follaje 15–25 × 0.7–2.3 cm y márgenes de la vaina pectinato-fimbriadas, mientras que **A. david-smithii** (Pasco) tiene lígulas interiores poco visibles, hojas de follaje 25–38 × 2.7–3.6 cm, los márgenes de la vaina con fimbrias confluentes densamente compactadas (estas divididas en última instancia) y fimbrias terminales de la vaina 10–15 mm de largo. Se presenta Una tabla para la comparación de las nuevas especies con sus parientes putativos *Aulonemia. humillima* y *A. parviflora*. Se incluyen imágenes de microscopia electrónica de barrido (SEM) de la epidermis abaxial de las hojas de ambas especies, así como una clave para el grupo de especies andinas de *Aulonemia* con espiguillas pequeñas.

KEY WORDS: Poaceae, Bambusoideae, Arthrostylidiinae, *Aulonemia*, Peru, neotropical bamboos

INTRODUCTION

The woody bamboo genus *Aulonemia* Goudot (Poaceae: Bambusoideae: Bambuseae: Arthrostylidiinae) exhibits undescribed diversity throughout the Andes (Clark 1995; Judziewicz et al., 1999) in Venezuela (Judziewicz et al. 1991; Judziewicz & Riina 2006), Colombia (Clark & Londoño 1990; Clark et al. 1997, 2007; Judziewicz et al. 2013), Peru (Judziewicz & Tyrrell 2007) and Bolivia (Judziewicz & Clark 2011; Judziewicz et al. 2010, 2011).

Several Peruvian species are notable for their effuse panicles of small spikelets and presence of leaf sheath marginal fimbriae. *Aulonemia parviflora* (J. Presl) McClure (Húanuco, Cusco) has robust foliage leaf blades (21–)35–52 cm long and (3–)3.7–5.8 cm wide that are strongly tessellate abaxially, and extraordinarily long, pale brownish inner ligules 40–80 mm long, and papery, confluent, non-splitting fimbriae on its foliage leaf sheath margins. On the other hand, *A. humillima* (Pilg.) McClure (Loreto or San Martín) has much smaller

non-tessellate foliage leaf blades 8–17 cm long and 0.7–1 cm wide with sheath margins bearing regularly spaced, discrete (non-confluent) marginal fimbriae, terminal sheath fimbriae 35–50 mm long, and inconspicuous inner ligules.

To this group of "small-spikeleted" taxa with marginal leaf sheath fimbriae may now be added two new Peruvian species (Table 1). *Aulonemia rubraligulata* Judz. & Geisthardt (Amazonas, Cajamarca, and Junín) has elongate, reddish inner ligules 20–45 mm long, foliage blades 15–25 cm long and 0.7–2.3 cm wide (that are not at all tessellate), and pectinate-fimbriate sheath margins, while *A. david-smithii* Judz. & Waas (Pasco) has inconspicuous inner ligules, foliage leaf blades 25–38 cm long and 2.7–3.6 cm wide, sheath margins with densely matted confluent fimbriae (these ultimately splitting) and terminal sheath fimbriae 10–15 mm long. Neither of these taxa is accounted for in treatments of Peruvian grasses (Tovar 1993; Brako & Zarruchi 1994).

KEY TO THE ANDEAN SPECIES OF *AULONEMIA*

WITH MARGINAL FIMBRIAE AND EFFUSE PANICLES OF SMALL, SLENDER SPIKELETS

1. Foliage leaves with inner ligules less than 1 mm long, the sheath summit with fimbriae 10–50 mm long
   2. Foliage leaf blades 25–38 cm long, 2.7–3.6 cm wide, the sheath margins with initially confluent (but ultimately splitting and matting) fimbriae; terminal sheath fimbriae 10–15 mm long; Dept. Pasco, 910 m _____ **A. david-smithii** Judz. & Waas
   2. Foliage leaf blades 8–17 cm long, 0.7–1 cm wide, the sheath margins with regularly spaced, discrete, marginal fimbriae; terminal sheath fimbriae 35–50 mm long; Dept. San Martín, 1200 m _____ **A. humillima** (Pilg.) McClure
1. Foliage leaves with inner ligules 20–80 mm long, the sheath summit efimbriate
   3. Foliage leaves blades (21–)35–52 cm long, (3–)3.7–5.8 cm wide, strongly tessellate abaxially; inner ligules 40–80 mm long, pale brownish; foliage leaf sheath margins with numerous papery, confluent, non-splitting fimbriae; Dept. Cusco and Huánuco, 1900–2100 m _____ **A. parviflora** (J. Presl) McClure
   3. Foliage leaves blades 15–25 cm long, 0.7–2.3 cm wide, not tessellate; inner ligules 20–45 mm long, reddish; foliage leaf sheath margins with numerous discrete (non-confluent) pectinate fimbriae; Dept. Amazonas, Cajamarca, and Junín, 1500–2200 m _____ **A. rubraligulata** Judz. & Geisthardt

Plant parts were measured using a mm ruler, and a portion of the abaxial leaf blade epidermis (from the central, non-marginal part of a well-developed blade) from one sample of both species was examined using air-dried, uncoated, untreated material in a Hitachi S3400 scanning electron microscope; specimens were examined from the following herbaria: F, K, MO, NY, P, US, UWSP, and WIS.

Aulonemia david-smithii Judz. & Waas, sp. nov. (**Figs. 1–3**). TYPE. PERU. PASCO. Prov. Oxapampa: W side of Cordillera de San Matías between Iscosacin and summit, 10°11'S, 75°12'W [probably 75°06'W according to Google Earth; 75°12' would place specimen in lowland forest at 325 m], 910 m, 22 Jun 1982, cloud forest with heavy bryophyte cover on ground and all plants, 2 m, in flower, *David N. Smith 2045* (HOLOTYPE: MO!; ISOTYPE: US!).

Bamboo 2 m tall; culms apparently less than 5 mm in diameter, glabrous. Midculm branching pattern and culm leaves not seen. Foliage leaves glabrous and smooth; sheaths strongly keeled, the midnerve prominent near the summit, the margins papery, chartaceous, and prominently cross-puckered on the lower leaves, on the upper leaves the sheath margins breaking up into very dense, curling, orangish-brown, prominent fimbriae 3–5 mm long, each fimbria attenuate into a mass of interwining excelsior-like, finely hispid apices; sheath summit lacking auricles, but with erect, brownish, hispidulous fimbriae 10–15 mm long; outer ligule varying from an indurate rim ca. 1 mm long to (one one side) an ovate, stramineous, shiny flange 2–4 mm long; inner ligule not evident, not large if present; pseudopetioles 2–4 mm long; blades 25–38 cm long, 2.7–3.6 cm wide, linear-lanceolate, erect, the apex long-acuminate, the base obtuse and symmetrical, moderately strongly tessellate below (abaxially), the margins scabrous and cartilaginous. Peduncle short or included in the uppermost leaf sheath. Inflorescence up to 25 cm long, 20 cm wide, an open ovoid panicle with smooth branches; primary branches ascending at a 45° angle, triquetrous, the secondary and tertiary branches triquetrous to capillary. Spikelets (all immature and not well-developed) at least 15 mm long, linear, sparsely flowered, greenish, awnless, glabrous; glumes linear-lanceolate, awnless, the lower glume at least 1 mm long, the upper glume at least 2 mm long, short-aristate, 3–5-nerved; lowest floret apparently sterile, lacking a palea, upper florets fertile, apparently 1–3, the lemmas 3.5–6 mm long, lanceolate, acute; paleas 1.8–3 mm long; flowers and fruits not seen.

Leaf micromorphology, abaxial surface (*Smith 2045*, MO). Terminology follows Ellis 1979; Fig. 3.

Costal zones.—Spaced ca. 250 µm apart.



Fig. 1. *Aulonemia david-smithii*. **A.** Foliage leaf complement and inflorescence. Based on *D.N. Smith 2045* (MO). Illustration by Eva C. Hathaway.

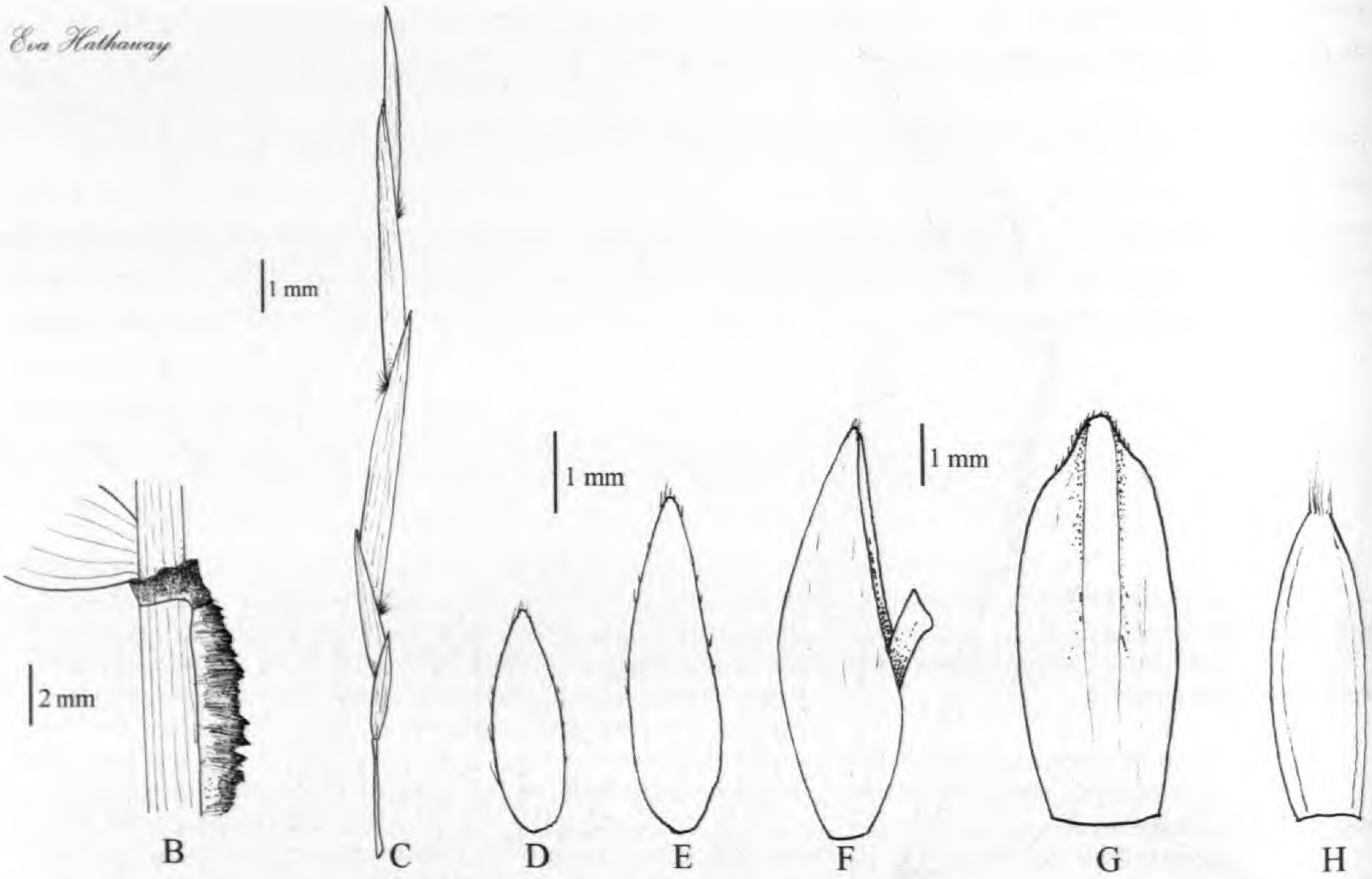


Fig. 2. **B.** Detail of foliage leaf showing matted confluent marginal fimbriae. **C.** Spikelet. **D.** Lower glume. **E.** Upper glume. **F.** Fertile lemma, lateral view. **G.** Fertile lemma. **H.** Palea. Based on *D.N. Smith 2045* (MO). Illustration by Eva C. Hathaway

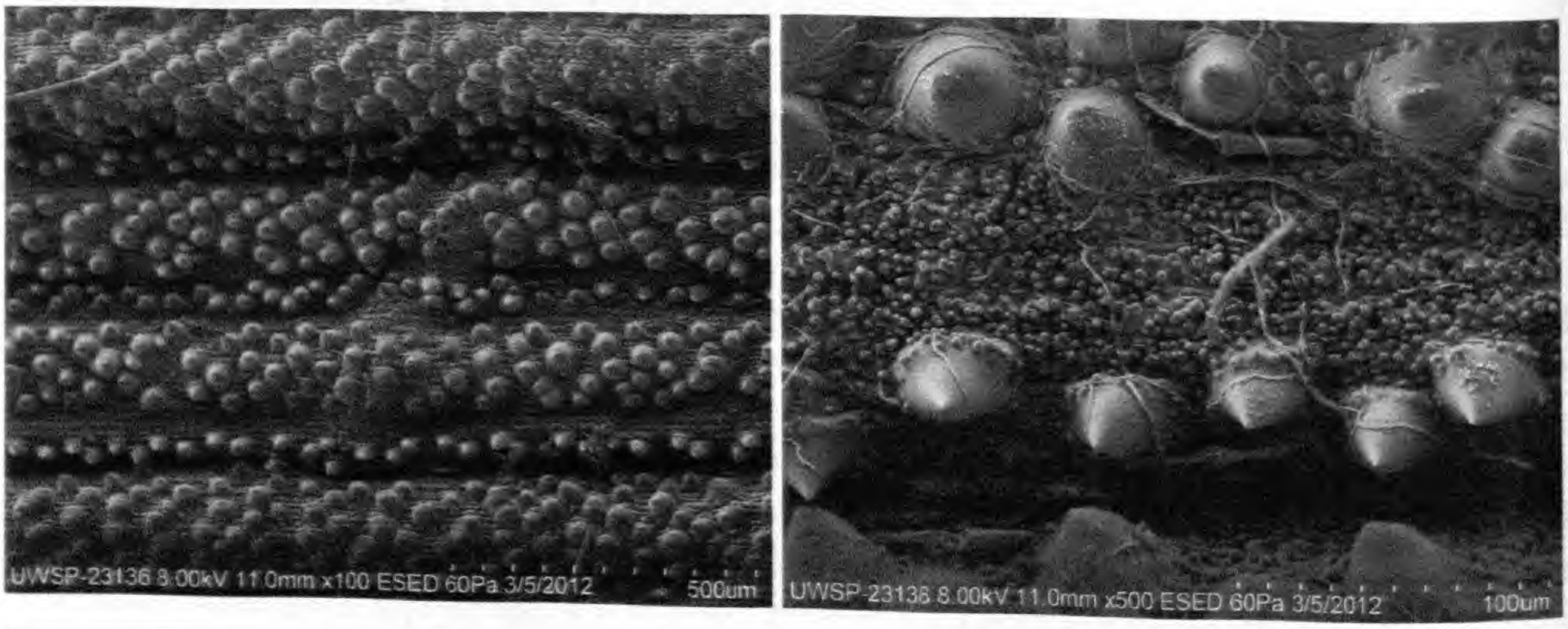


Fig. 3. Scanning electron micrographs (SEMs) of abaxial (lower) foliage leaf blade epidermis of *Aulonemia david-smithii* (*Smith 2045*, MO). **A.** Showing four costal zones and abundant conical prickles. **B.** Showing prickles, dense papillae nearly concealing stomates, and bicellular microhairs with deflated apical cells.

Papillae.—Abundant; globose to slightly compound; 4–6 µm in diameter.

Stomata.—Common; stomata alternating; stomatal rows 4–5, adjacent to costal zones. Four overarching branched papillae present at each of the corners, giving the stomatal apparatus a plus sign (+) shape.

Interstomatal cells.—ca. 20–30 µm long, outline indeterminate; papillae present, abundant, globose to slightly compound, uniform in size.

Long Cells.—Dimensions difficult to discern due to dense papillae.

Prickles.—Abundant, ca. 4/10,000 µm²; mostly in intercostal zones, but present in costal zones; 30–50 µm long, 30–50 µm wide, tapered to a sharp tip, like a candy kiss.

Short Cells.—Difficult to discern due to dense papillae.

Microhairs.—2–celled, 55–60 µm long; basal cell 28–33 µm long, 7–10 µm wide; apical cell deflated, ca. 30 µm long.

Macrohairs.—None seen.

Aulonemia david-smithii is distinctive in its densely matted orangish marginal fimbriae (densest in the genus), as well as the *Aulonemia queko* Goudot -like flange at the summit of the leaf sheath, effuse panicle with small spikelets, and somewhat abaxially tessellate leaf blades. The species is known from just a single collection made on the ridgetop cloud forest summit of the north-south trending Cordillera de San Matías in Oxapampa, Pasco, Peru, at an elevation of 910 m. It is named after David N. Smith (1945–1991), assiduous collector of the Peruvian and Bolivian flora for the Missouri Botanical Garden. Smith gave the longitude as 75°12'W, but from his field notes and label description, the collection was probably made at the summit of the cordillera at 75°06'W (according to Google Earth); 75°12' would place the collection in lowland forest at 325 m elevation. From Tropicos (accessed 24 April 2012), Smith's collections from that site included many ferns and epiphytic shrubs, with no vegetation greater than 6 m tall. Brako & Zarucchi (1994) cited *Smith 2045* as *A. humillima*, but that species is known only from the type and lacks confluent marginal fimbriae, has shorter sheath summit fimbriae, and has shorter, narrower leaf blades.

Aulonemia rubraligulata Judz. & Geisthardt, sp. nov. (**Figs. 4–5**). TYPE. PERU. CAJAMARCA: Prov. San Ignacio: San José de Lurdes, Santo Tomas, 4°55'S, 78°50'W, 2200 m, bosque primerio, trepadora, espigas verdosas, 15 Jun 1995, *R. Vásquez, Camilo Díaz & Aurelio Torres 20216* (HOLOTYPE: USM; ISOTYPES: MO!, US!, UWSP!).

Scrambling or climbing woody bamboo; culms ca. 3 mm in diameter, reportedly up to 8 m long, smooth. Culm leaves apparently not differentiated from foliage leaves. Midculm nodes bearing single, divergent branches. Foliage leaves with sheaths glabrous, stramineous to greenish, striate, the margins with abundant recurved stramineous pectinate fimbriae 2–4 mm long spaced about 7–10 per cm, or when young confluent into a chartaceous membrane; sheath summit lacking auricles and fimbriae; outer ligule ca. 1 mm long, indurate, stramineous, prolonged on one side into an ovate stramineous, shiny flap 1.5–3.5 mm long; inner ligule 20–45 mm long, membranous, linear-lanceolate, acute, glabrous, reddish when young fading to stramineous with age; pseudopetioles 2–3 mm long; blades 15–25 cm long, 0.7–2.3 cm wide, linear-lanceolate, reflexed or the upper ascending, the apex long-acuminate, the base acute, symmetrical, and with a slight crassulate hastula along the midrib abaxially, the blades concolorous, glabrous, antrorsely scabrous marginally, and etessellate. Peduncle up to 8 cm long. Inflorescence terminal, 8–20 cm tall, an open, ovoid panicle; branches all capillary, smooth, the main ones ascending at a 45° angle. Spikelets (12–)17–25 mm long, ca. 2 mm wide, linear, delicate, greenish to reddish, loosely 5–8-flowered, the lowest floret sterile; glumes linear-lanceolate, acute, glabrous, the lower glume 1–1.5 mm long, 1-nerved, the upper glume 2–2.5 mm long, 1–3-nerved; lowest (sterile) lemma 2.5–3 mm long, lanceolate, acute, 1–3-nerved; fertile florets 4–7, the lemmas 4.6–5.3 mm long, narrowly lanceolate, acute, 5–7-nerved, glabrous except for a fine beard of callus hairs 0.3–0.4 mm long at the base; rachilla internodes 2.7–3.3 mm long, exposed in their upper halves, glabrous except for some fine ascending puberulence in the exposed portions; paleas usually slightly shorter than and concealed by the lemmas; uppermost floret frequently smaller and rudimentary; lodicules 3, rhombic, 1.2–1.5 mm long, 3-nerved, pubescent at the apex; stamens 3, the immature anthers ca. 1 mm long; pistil with 2 immature stigmas; fruit not seen.

Additional specimens examined: **PERU. AMAZONAS:** ca. 12–18 km by trail E of La Peca, Serrania de Bagua, 1800–1950 m, lower montane cloud forest, 14 Jun 1978, in disturbed area of forest, *Gentry et al. 22898* (MO, US). **CAJAMARCA: Prov. San Ignacio:** troche limite con "La Unión," 2200 m, 1 Nov 1995, dominante, alcanza hasta 6–8 m, espigas rojizas, *Camilo Díaz & Aurelio Torres 7828* (MO, US, UWSP). **Prov. Ignacio:** localidad Jorge Chávez, 5°S, 78°55'W, 2000 m, 19 Mar 1997, primary forest, *J. Campos & S. Corrales 3567* (MO, US, UWSP). **JUNÍN:** Pichis trail, Porvenir, 1500–1900 m, 3–4 Jul 1929, dense forest, *Killip & Smith 25959* (NY, US).

Leaf micromorphology, abaxial surface (*Díaz & Torres 7828*, UWSP). Terminology follows Ellis 1979; Fig. 5. *Gentry et al. 22898* (MO) was also examined and exhibited a similar micromorphology.

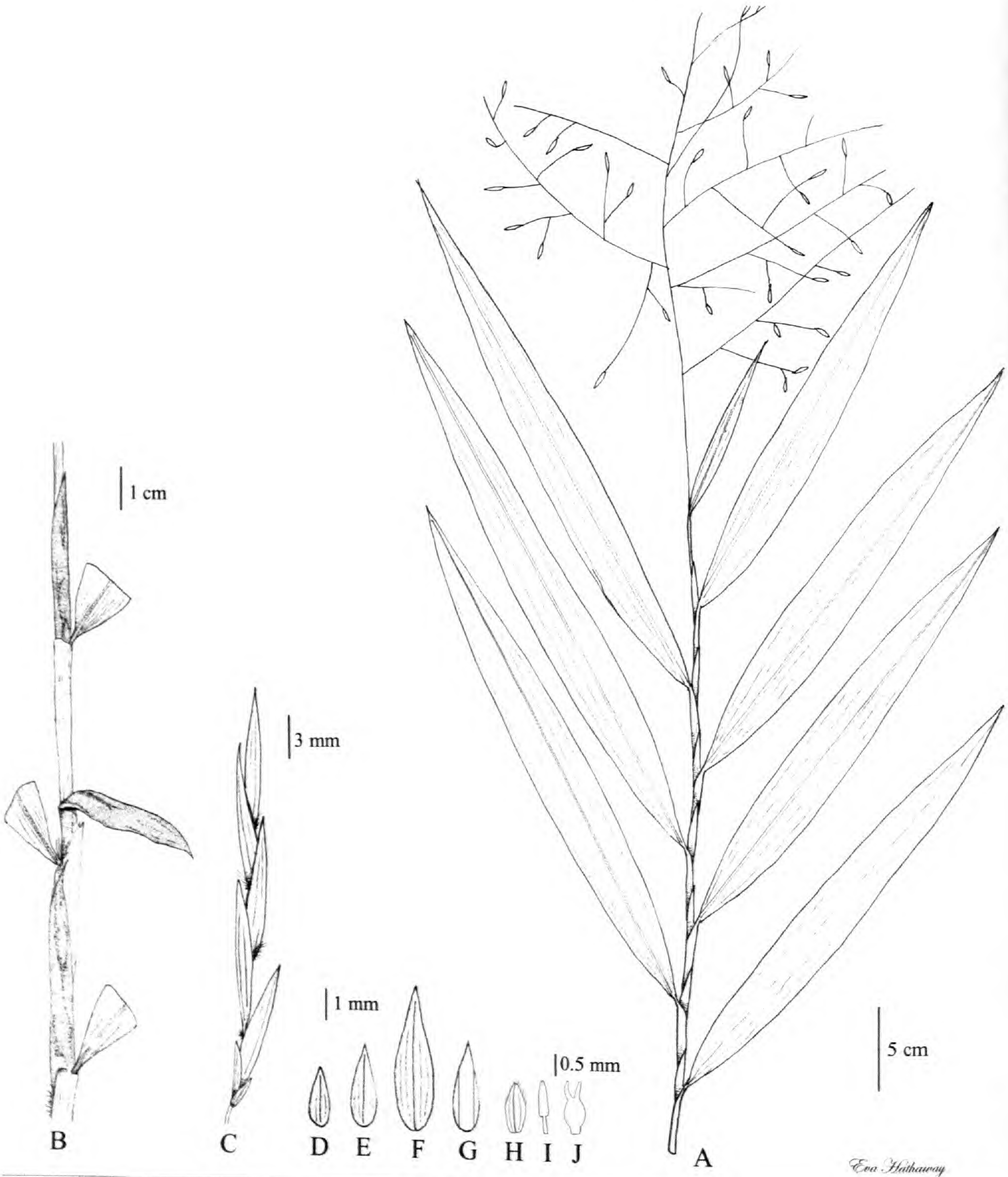
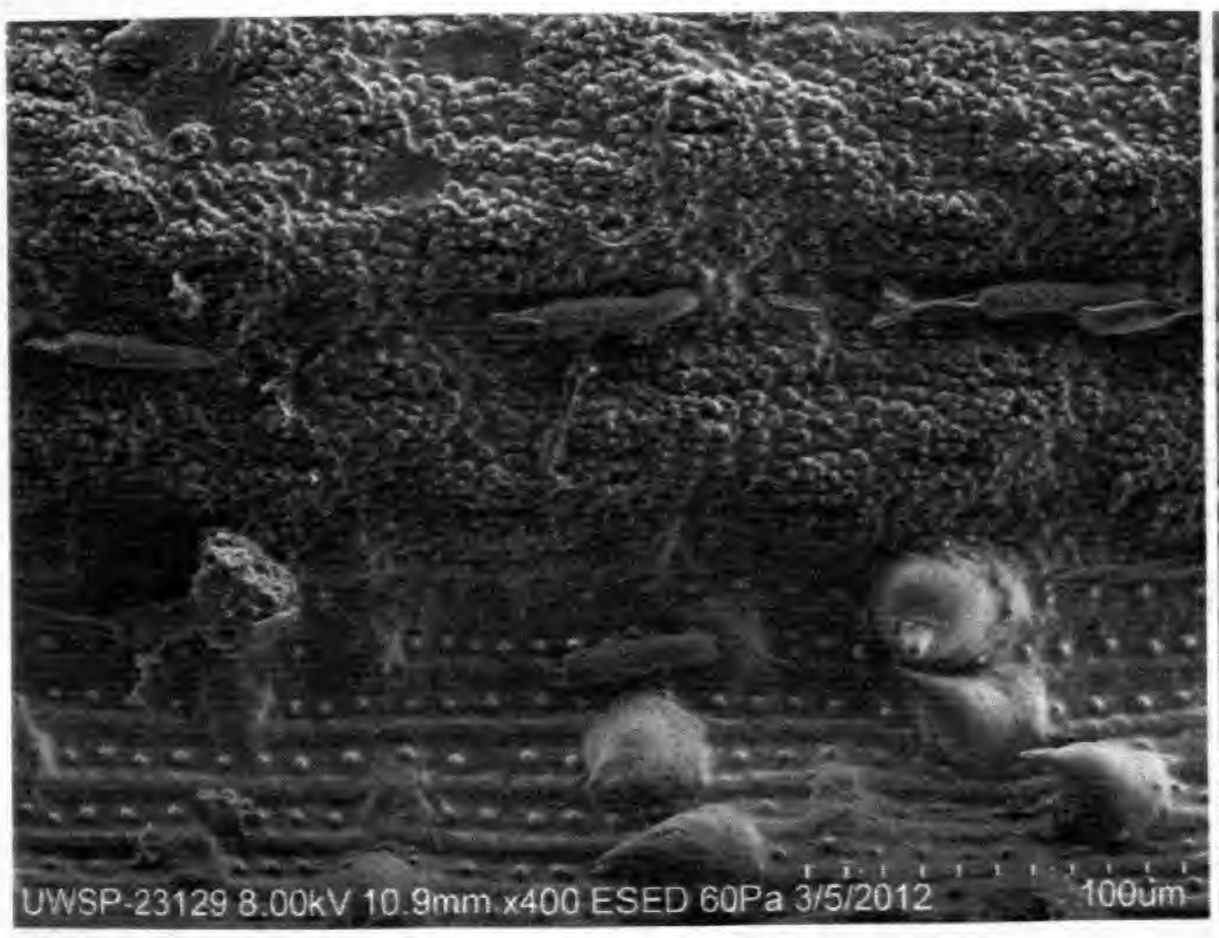


Fig. 4. *Aulonemia rubraligulata*. **A.** Foliage leaf complement and inflorescence. **B.** Detail of culm showing portions of three foliage leaves, each with a prominent inner ligule. **C.** Spikelet. **D.** Lower glume. **E.** Upper glume. **F.** Fertile lemma, dorsal view. **G.** Palea. **H.** Lodicule. **I.** Stamen. **J.** Pistil. A–B based on *Díaz & Torres 7828* (MO), C–G based on *Campos & Corrales 3567* (UWSP). Illustration by Eva C. Hathaway

Costal zones.—Spaced ca. 200 µm apart.

Papillae.—Abundant in intercostal zones, absent in costal zones; globose to slightly compound; 3–6 µm in diameter.

Stomata.—Common; stomata alternating; stomatal rows 4–6, adjacent to costal zones. Four overarching branched papillae present at each of the corners, giving the stomatal apparatus a plus sign (+) shape.



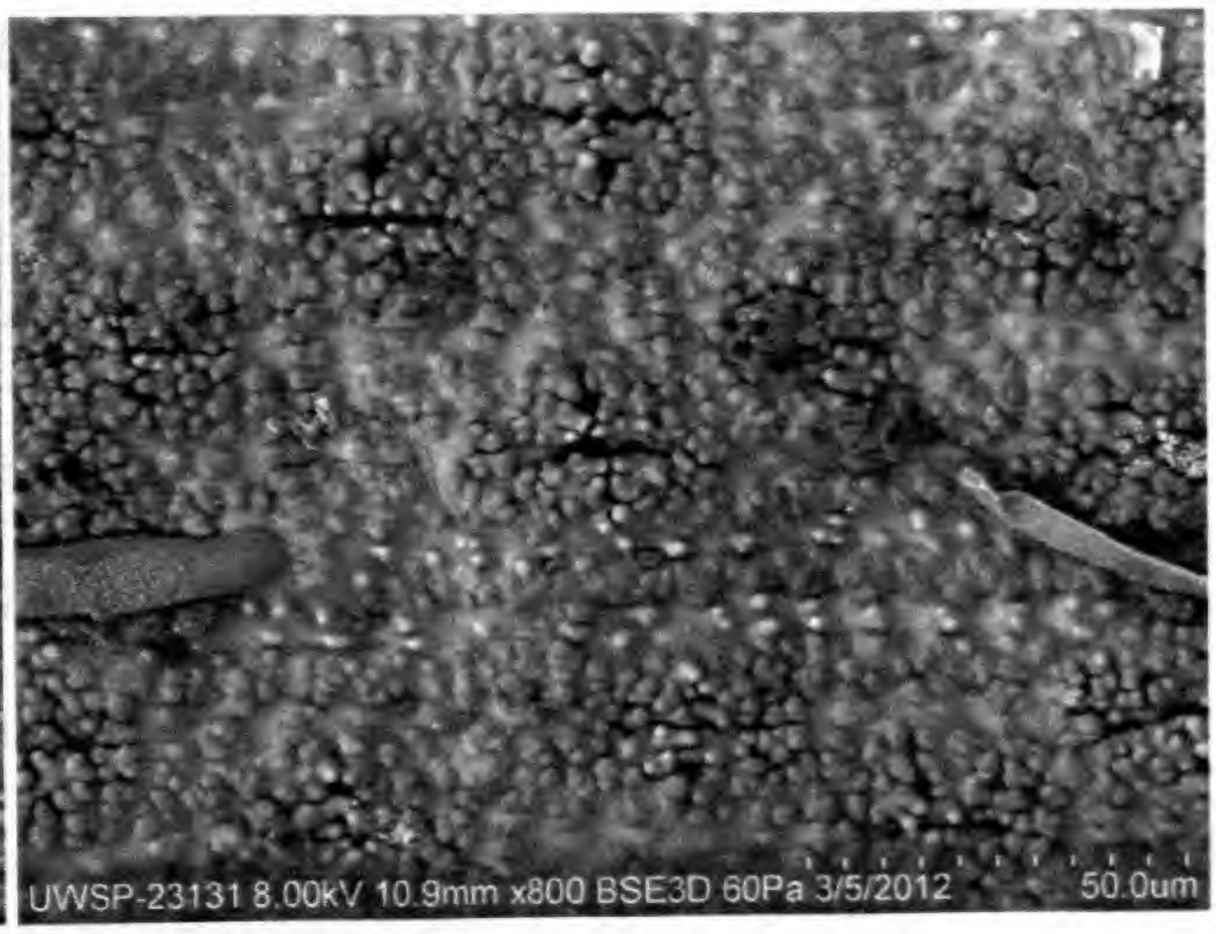


Fig. 5. Scanning electron micrographs (SEMs) of abaxial (lower) foliage leaf blade epidermis of *Aulonemia rubraligulata* (*Díaz & Torres 7828*, UWSP). A. Showing papillose intercostal zones and non-papillose costal zone. B. Showing prickles, dense papillae nearly concealing stomates, and bicellular microhairs with deflated apical cells.

Interstomatal cells.—Ca. 40–50 µm long, outline indeterminate; papillae present, abundant, globose to slightly compound, uniform in size.

Long Cells.—Dimensions difficult to discern due to dense papillae.

Prickles.—Common, ca. 3–4/10,000 µm²; 35–45 µm long, 40–50 µm wide, tapered to a sharp tip, like a candy kiss.

Short Cells.—Difficult to discern due to dense papillae.

Microhairs.—2–celled, 75–80 µm long; basal cell 45–50 µm long, 7–10 µm wide; apical cell deflated, ca. 30 µm long.

Macrohairs.—None seen.

Aulonemia rubraligulata is endemic to cloud forests in northern and central Peru at elevations from 1500–2000 m; it may eventually be found in neighboring Ecaudor, since one collection is only 8 km from the border of that country. The prominent reddish (when fresh) inner ligule 20–45 mm long is unique in the genus and prompted the specific epithet. Tovar (1993) cited *Killip & Smith 25959* as *A. humillima*, but that species is known only from the type, is smaller of stature, has inconspicuous ligules, elongate leaf sheath summit fimbriae and smaller spikelets with fewer florets.

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TWO NEW NORTHERN ANDEAN SPECIES OF *AULONEMIA* (POACEAE: BAMBUSOIDEAE: BAMBUSEAE: ARTHROSTYLIDIINAE) WITH VERRUCOSE CULMS

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ABSTRACT

Aulonemia notata and **A. verrucosa** are two distinctive new Colombian and Venezuelan species of vining bamboos (Poaceae: Bambusoideae: Bambuseae: Arthrostylidiinae) with verrucose culms having raised dark siliceous dots and purple-maculate spikelets. *Aulonemia notata*, from the Cordillera Oriental in Táchira, Venezuela, has awnless spikelets 22–35 mm long with florets 9–10.5 mm long, while *A. verrucosa*, from the Cordillera Central and Serranía de Perijá in Colombia, has larger, awned spikelets 40–70(–80) mm long, with larger florets 13–16 mm long. These species are described and illustrated. A key to the species of *Aulonemia* with verrucose culms is also provided.

RESUMEN

Aulonemia notata y **A. verrucosa** son dos nuevas especies diferenciables de bambúes trepadores de Colombia y Venezuela (Poaceae: Bambusoideae: Bambuseae: Arthrostylidiinae), con culmos verrugosos, cubiertos por puntos protuberantes y silíceos oscuros y por espiguillas maculadas de púrpura. *Aulonemia notata* ocurre en la Cordillera Oriental en el Estado de Táchira, Venezuela, tiene espiguillas no aristadas de 22–35 mm de longitud con flósculos de 9–10.5 mm de longitud, mientras que *A. verrucosa* ocurre en Colombia en la Cordillera Central y en la Serranía de Perijá, y tiene espiguillas aristadas de mayor tamaño, 40–70(–80) mm de longitud, con flósculos más largos 13–16 mm de longitud. Estas especies son descritas e ilustradas. Se incluye también una clave para las especies de *Aulonemia* con culmos verrugosos.

KEY WORDS: Poaceae, Bambusoideae, Arthrostylidiinae, *Aulonemia*, Colombia, Venezuela

INTRODUCTION

Exploration of the northern Andes continues to reveal new species in the woody bamboo genus *Aulonemia* Goudot (Poaceae: Bambusoideae: Bambuseae: Arthrostylidiinae). In the last two decades novelties have been described from Venezuela (Judziewicz et al. 1991; Judziewicz 2004; Judziewicz & Riina 2005), and Colombia (Clark & Londoño 1990; Clark et al. 1997, 2007). This study is based upon examination of material from these herbaria: CAS, COL, F, K, MO, ISC, NY, P, UC, US, TULV, UWSP and WIS. Two distinctive new species may now be added to the genus. Both are delicate, vining bamboos with raspy culms that have the appearance and texture as if gritty bits of purple sand have been embedded in the surface (of evident utility when climbing) of the culms. Verrucose, "raspy" culms are otherwise known in *Aulonemia* only in several southern Brazilian and Argentinian species formerly placed in the segregate genus *Colanthelia* McClure & E.W. Smith (Judziewicz et al. 1999; Tyrrell et al. 2012; Santos-Gonçalves et al., in prep.). The species of *Aulonemia* with verrucose culms may be distinguished by the following key:

1. Fertile florets 13–16 mm long, tipped with awns 3–6 mm long; foliage leaf blades 9–17 cm long, 1.7–2.8 cm wide; Colombia _____ **A. verrucosa** Londoño, Judz. & L.G. Clark
1. Fertile florets 7–10.5 mm long, awnless (some species mucronate); foliage leaf blades 2–13 cm long, 0.3–1.7 cm wide.
   2. Fertile florets 2(–3), 4–5 mm long; spikelets 9–11 mm long; Brazil _____ **A. lanciflora** McClure & L.B. Smith [*Colanthelia lanciflora* McClure & L.B. Smith) McClure]
   2. Fertile florets 3–16, 6–10.5 mm long; spikelets 8–80 mm long.
      3. Fertile florets 9–10.5 mm long; Colombia _____ **A. notata** McClure ex Judz., L.G. Clark & Londoño
      3. Fertile florets 7–9 mm long; Brazil.
         4. Foliage leaf sheaths without auricles; fertile florets 5–16 (typically at least 7) _____ **A. intermedia** McClure & L.B. Smith [*Colanthelia intermedia* McClure & L.B. Smith) McClure]
         4. Foliage leaf sheaths bearing fimbriate auricles; fertile florets 3–8.
            5. Culm leaf sheaths without apical fimbriae or auricles; fertile florets 8–9 mm long _____ **Colanthelia burchellii** (Munro) McClure [not yet transferred into *Aulonemia*]
            5. Culm leaf sheaths bearing apical fimbriae and sometimes also inconspicuous auricles; fertile florets 8–11 mm long _____ **A. cingulata** McClure & L.B. Smith [*Colanthelia cingulata* McClure & L.B. Smith) McClure]

Many of the Brazilian congeners of *Aulonemia notata* and *A. verrucosa* in the key above also have purple-spotted glumes and lemmas; this character is otherwise known in *Aulonemia* only in the Costa Rican endemic *A. viscosa* (Hitchc.) McClure, a much more robust, larger-leaved species with smooth, viscid culms.

Aulonemia notata McClure ex Judz., L.G. Clark & Londoño, sp. nov. (**Fig. 1a-e**). TYPE: VENEZUELA. TÁCHIRA: between Villapaez [*sic*, for Villa Páez, 7°29'N, 72°27"W] and Betania [7°27'N, 72°26'W], along Río Tachira, bordering Colombian-Venezuelan boundary, 7000–7500 ft [2130–2285 m], 12 Jul 1944, climbing, flowers purple; NV: pajilla or corta calsón, *Steyermark 57165* (HOLOTYPE: VEN; ISOTYPES: F-3, US-2).

Vining, climbing bamboo with slender culms ca. 2 mm in diameter, the internodes hollow, verrucose, purple-maculate, the nodes with 1 mm thick girdle present. Nodes slightly swollen, producing 1–3 subequal branches. Culm leaf sheaths 2.5–3.5 cm long, bladeless (in available material), striate, glabrous, the apex acute or truncate. Foliage leaves in complements of 3–5; sheaths glabrous, purple-maculate, the margins smooth; sheath auricles absent; fimbriae confined to sheath summit, 4–8 mm long, delicate, purple or golden, basally erect, apically curling, easily rubbed off, excelsior-like; outer ligule 0.1–0.2 mm long, glabrous, shiny, stramineous, ciliolate-margined; inner ligule 0.2–0.3 mm long, brown, puberulous, ciliate-margined; pseudopetioles 2–3 mm long, glabrous, stramineous; blades 6–8 cm long, 1.2–1.6 cm wide, lanceolate, strongly reflexed, slightly asymmetrical at the base, long-acuminate at the apex, glabrous, concolorous or with a slightly darker stripe along one margin beneath. Synflorescence usually with base included in uppermost leaf sheath, paniculate 6–12 cm tall, 4–8 cm wide, ovoid, delicate, the branches lax, smooth and capillary; spikelets 22–35 mm long, 3–5-flowered, glabrous or very finely puberulent throughout and finely maculate with purple spots; lower glume absent or represented by a scalelike bract 0.2–0.4 m long often present 0.5–1 mm below spikelet; second glume obtuse, narrowly elliptical to broadly lanceolate, awnless, obtuse, 7.5–9 mm long, 5–7-nerved; lowest floret apparently staminate only, the upper florets 1–3, fertile, 9–10.5 mm long, lanceolate, acute to apiculate (apiculi best developed on apical lemmas and then up to 0.7 mm long), 7–9-nerved; paleas 6–8 mm long, narrowly lanceolate, shorter and narrower than the lemmas, bicarinate, ciliolate on the keels, minutely bifid. Flowers with lodicules not evident in spikelets examined; stamens apparently 2, the anthers 2.7–3.5 mm long, yellow-brown; gynoecium not seen. Fruit not seen.

Known from one collection in Venezuela made along the Río Táchira on the Colombian border. *Aulonemia notata* is clearly related to the Colombian endemic *A. verrucosa*; the latter species has larger spikelets 40–70(–80) mm long, with longer (13–16 mm) florets with 3–6 mm long awns. Based on annotations on the US isotype made by the late Thomas R. Soderstrom in 1974, Floyd A. McClure (1897–1970) recognized that this species was undescribed and suggested the epithet "*notata*", doubtlessly an allusion to the maculate culms and spikelets. The spikelets are peculiar in that they lack a well-developed lower glume; the second glume is large and well-developed, and the succeeding floret appears to be staminate.

Aulonemia verrucosa Londoño, Judz. & L.G. Clark, sp. nov. (**Figs. 1f-l, 2–3**). TYPE. COLOMBIA. ANTIOQUIA: Municipio Entrerrios, ca. 3 km from Entrerrios [6°33'58'N, 75°31'03"W on Google Earth] on road to Santa Rosa de Osos [6°38'56"N, 75°27'48"W on Google Earth], downstream from bridge along Rio Grande, 6°32'N, 75°30'W, 2250 m, common much-branched scandent grass, spikelets dark maroon, 5 Feb. 1989, *J.F. MacDougal & F.J. Roldán 3664* (HOLOTYPE: HUA; ISOTYPES: ISC, MO-2, UWSP).

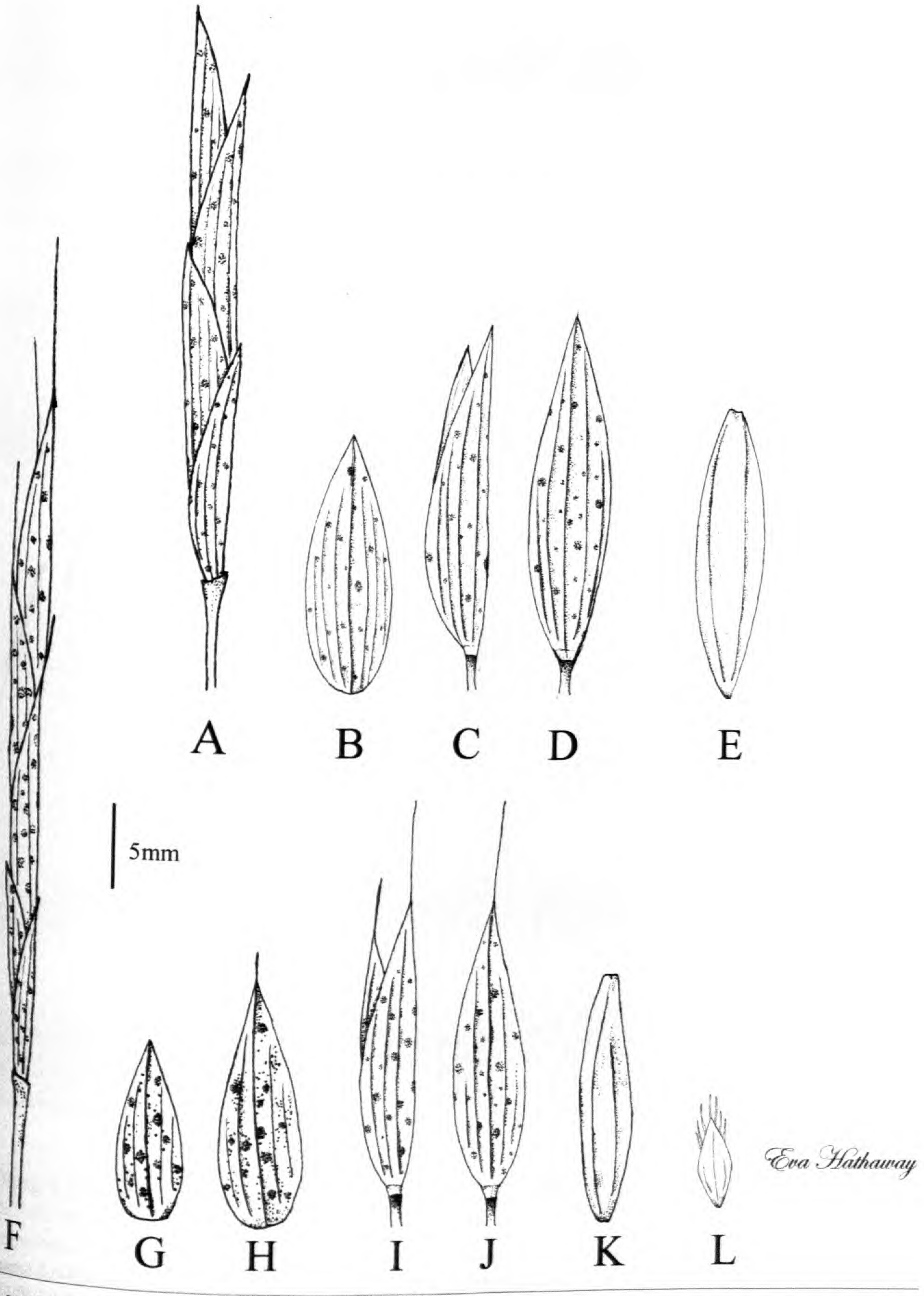


Fig. 1. Spikelets of *Aulonemia notata* (**A-E**) and *A. verrucosa* (**F-L**). **A.** Spikelet, lateral view. **B.** Upper glume, dorsal view. **C.** Fertile floret, lateral view. **D.** Fertile floret, dorsal view. **E.** Palea, dorsal view. **F.** Spikelet, lateral view. **G.** Lower glume, dorsal view. **H.** Upper glume, dorsal view. **I.** Fertile floret, lateral view. **J.** Fertile floret, dorsal view. **K.** Palea, dorsal view. **L.** Lodicule. *Aulonemia notata* based on *Steyermark 57165* (US); *A. verrucosa* based on *MacDougal & Roldán 3664* (ISC, UWSP). Illustration by Eva C. Hathaway.



Fig. 2. *Aulonemia verrucosa*. **A.** Habit showing branching and culms. **B.** Detail of branching. **C.** Culm internode showing verrucose papillae. **D.** Segment of culm showing three culm leaves. **E.** Base of foliage leaf blade showing delicate fimbriae. Based on *Cuatrecasas & R. Romero-Castañeda 25306* (US). Illustration by Eva C. Hathaway.

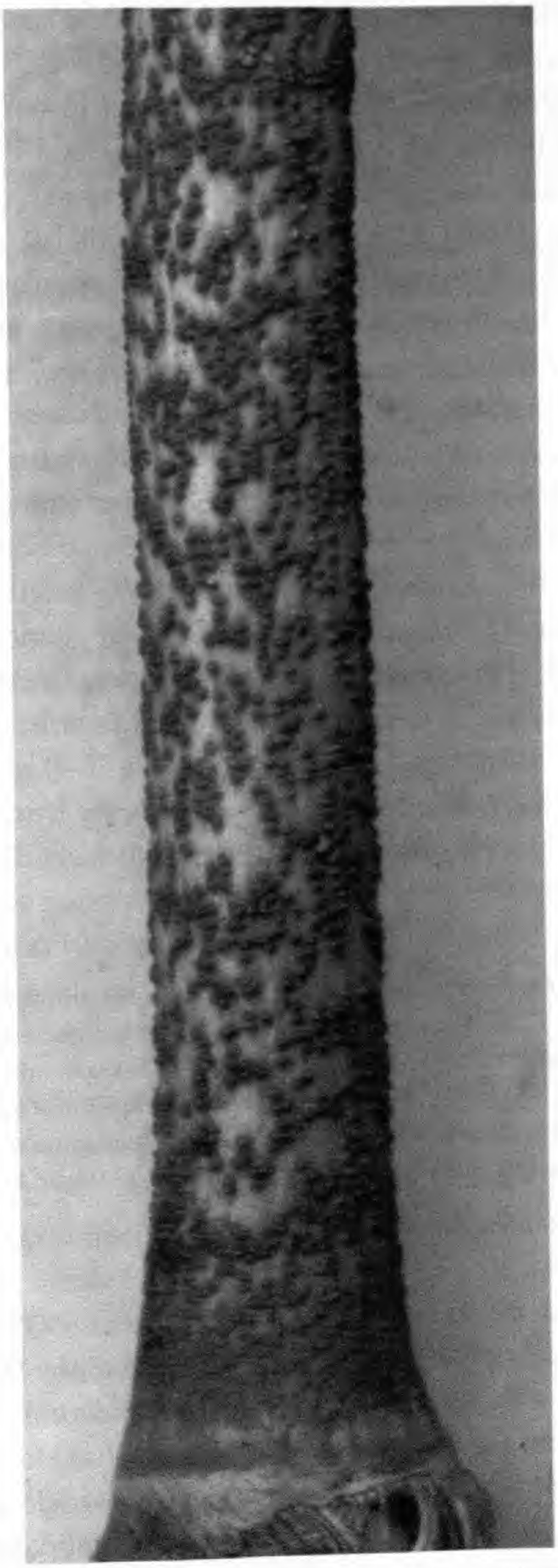


Fig. 3. *Aulonemia verrucosa*. Culm internode showing verrucose papillae. *Cuatrecasas & R. Romero-Castañeda 25306* (US).

Vining, scandent, delicate, intricately-branched bamboo. Culms 1.5–4 mm in diameter, hollow with a lumen ca. ⅓ the diameter of the culm, glabrous, stramineous, the larger, older culms densely verrucose with raised purple-black siliceous papillae about 130–180 µm in diameter and 45–100 µm tall, the more slender, upper portions of the culms merely purple-maculate with papillae absent. Nodes slightly swollen, with an evident girdle 1–2 mm wide, producing (on lower, large culms) 1 strongly ascending branch with a distal internode ca. 1 cm long, the first node producing primordia that may develop into adventitious roots, the upper nodes producing up to 3 subequal branches. Culm leaves (seen only in Dept. Magdalena collections) with a skirt present at juncture of sheath and girdle, the sheaths 3–5 cm long, striate orangish-brown, the margins finely ciliolate, the apex acute, truncate, or slightly concave, glabrous or (if concave) fringed with a few delicate 2–3 mm gold-

en-brown fimbriae, the inner ligule 0.3–0.5 mm long, puberulous, the blades 7–12 mm long, 1.5–3 mm wide, ovate-lanceolate, ascending, divergent, or reflexed, pubescent, deciduous. Foliage leaves in loose complements of 3–5; sheaths glabrous, striate, stramineous or obscurely green-maculate, often strongly suffused with purple near the summit, lacking auricles but one side of the sheath summit elevated by 1 mm as a "shoulder"; marginal fimbriae absent, terminal fimbriae usually absent, if present then sparse, delicate, and 4–10 mm long; outer ligules 0.2–0.3 mm long, indurate; inner ligules 0.2–0.4 mm long, ciliolate; pseudopetioles 2–5 mm long, purplish, adaxially pubescent; blades 9–17 cm long, 1.7–2.8 cm wide, lanceolate, ascending to reflexed, obtuse to somewhat asymmetrical to very slightly subcordate at the base, long-acuminate at the apex, glabrous above, glabrous to sparsely puberulent beneath, the margins cartilaginous and antrorsely scabrous, concolorous or with a slightly darker stripe along one margin beneath. Peduncle 2–5 cm long, glabrous. Synflorescence an ovoid panicle 10–22 cm tall, 8–15 cm wide, the few branches lax and capillary, the spikelet pedicels all glabrous and smooth. Spikelets 40–70(–80) mm long, slender, stramineous but strongly suffused with purple due to the abundant purple spots, finely and densely appressed-puberulent to pubescent throughout, the florets overlapping such that the summit of one floret extends about halfway up the length of the succeeding floret; scalelike bract 0.3–1 mm long often present 0.5–1 mm below spikelet; lower glume 7–12 mm long, linear-lanceolate, acute to apiculate, 5–7(–9)-nerved; upper glume 9–13 mm long, linear-lanceolate to lanceolate, acute to apiculate, 7–9-nerved; fertile florets 4–6, the lowermost floret sometimes sterile, the uppermost 1 or 2 floret(s) sterile; fertile florets with lemmas 13–16 mm long, lanceolate, finely 5–7(–9)-nerved, abruptly tipped with an antrorsely scabrous awn 3–6 mm long; paleas 8–13 mm long, narrowly lanceolate, shorter and narrower than and concealed by the lemmas, bicarinate, ciliolate on the keels, minutely bifid. Flowers with lodicules 3, 0.8–1.2 mm long, rhombic, acute, transparent, obscurely 2–3-nerved, tipped with erect clear cilia 0.3–0.5 mm long; stamens 3, the anthers 4 mm long, linear; pistils with 2 hispid stigmas. Fruit not seen.

Other specimens examined: **COLOMBIA. CESAR/MAGDALENA:** Mpio. Manaure, Serranía de Perijá, via Manaure-Sabana Rubia, between Finca Inglaterra and El Cinco, 10°23–24'N, 72°59"W, 2200 m, 24 July 1989, somewhat disturbed primary montane forest, sterile bamboo at edge of forest, culms viny, delicate, no more than 2–3 mm diam, forming a tangled mass, culm leaves with a skirt present at juncture of sheath and girdle, *X. Londoño & L. Clark 472* (COL, ISC, TULV, US); Serranía de Perijá, E of Manaure, Hoya del Río Manaure, San Antonio, 1700 m, 14 Nov. 1959, subandean high forest, canes branched, intricate, sterile, *J. Cuatrecasas & R. Romero-Castañeda 25306* (US-4 sheets; the COL sheet of this number is the panicoid grass *Lasiacis sorghoidea* (Desv. ex Ham.) Hitchc. & Chase).

Aulonemia verrucosa is a vining species that has culms with distinctive raised siliceous purple "warts", and elongate, slender, awned, purple-maculate spikelets. A Colombian endemic, it occurs in the Cordillera Central of Antioquía and in the Serranía de Perijá in Cesar/Magdalena about 500 km to the northeast, at elevations from 1700–2250 m (and perhaps up to 2620 m). It is clearly related to the Venezuelan endemic *A. notata*; the latter species has smaller, awnless spikelets 22–35 mm long with florets only 9–10.5 mm long.

The fertile type specimen from the Department of Antioquía has efimbriate foliage leaves with blades 9–12 cm long and 1.7–2.2 cm wide while the sterile Department of Magdalena collection has larger leaf blades 12–17 cm long and 2–2.8 cm wide, and sheaths with well-developed fimbriae 4–10 mm long; it could represent a separate taxon, but we await fertile material before describing it as such.

ACKNOWLEDGMENTS

We thank UWSP student Eva C. Hathaway for the line drawings, Shingo Nozawa for checking on the VEN holotype of *Aulonemia notata*, Gerrit Davidse (MO) for the loan of specimens and assistance, and Pedro Viana and an anonymous reviewer for helpful comments.

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BOOK REVIEW

LYTTON JOHN MUSSELMAN AND HAROLD J. WIGGINS. 2013. **The Quick Guide to Wild Edible Plants.** (ISBN: 978-1-4214-0871-2, cloth). The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363, U.S.A. (**Orders:** www.press.jhu.edu, 1-800-537-5487). $24.95, 144 pp., 116 color photos, 5 ½" × 8 ½".

Growing up in New England and spending much time in the Mid-Atlantic States, I was interested to get my hands on this little book to see what I knew about wild edible plants in my native habitat, and I was pleasantly surprised. Musselman and Wiggins offer us an easy-to-use guide to common edible plants of the Eastern Seaboard, most of which I am familiar with, some of which I have tried, and a number that sound, well … interesting and worth an experimental taste test.

It is a self-described "quirky" guide which offers recipes for 31 wild edible plants, everything from aperitifs to sweets. In fact, the guide is developed almost like a cookbook, starting with condiments, ranging through greens and starches, and ending with cordials. The authors have a great sense of humor as they describe their many plant collecting forays "crossing icy streams in winter and tenacious miasmic mud in scorching summer heat … thorns and spines … clouds of insects … extracting plants from muck that seemed to extend to Middle Earth … boiled, parched, ground, baked, and dehydrated only to find that what remained was a taste that would gag a maggot."

The authors don't attempt to cover every possible edible plant out there, but they have picked some great ones. It is a fast and easy read. Their recipes use few ingredients so as not to distract from the true flavor of the plant and were tested over many years on their sporting families and students. The authors provide botanical information on each of the plants and a cautionary overview of some of the key ones to avoid such as Poison Ivy and Poison Oak.

Reading this guide, I was initially puzzled over who, exactly, was the target audience. It is not meant as a survival guide for people dependent on foraging for existence as many of the recipes require patience on the part of the gatherer for the precise moment when the plant is in bloom or ready to harvest. For example, in describing the recipe for Cane Crispies, the authors admit to finding fruiting cane only 3 times in their 75 years of combined field work—though they claim it was worth the wait and search. It is hard to imagine someone lost in the Appalachian Mountains for that long. Then it began to dawn on me, the book was intended for those with enough background on plants to not make grave errors like the demise of Socrates, drinking Poison Hemlock. It is targeted for those of us who aren't dependent on foraging for survival, those with a love of the out-of-doors, with a willingness to get a little dirty and to try new things. The book is intended for someone like … me!

From Cattail Corn Dogs to Pickled Orange Day Lily Buds (or Ditch Lilies as we used to call them) there are delectable treats to be had for the patient forager. How about some Black Locust Flower Fritters or Redbud Flowers on one's salad or ice cream? Yum! I've tried Nettle Omelets, Field Garlic, and Sassafras Tea. The one which I would love to try, and better yet, find a market for, is Crunchy Kudzu Leaf Chips. Just think … a new snack food with a never-ending supply; although, we might have to change the name from Kudzu to something more palatably attractive.

My favorite recipe in the book, however, is the Mussleman and Wiggins Wild Blueberry Cordial. Having spent many a summer at my step-father's rustic camp in Washington County, Maine, responsible for 90% of the nation's wild blueberry crop, I thought I had tried every blueberry concoction possible. I obviously missed one. I look forward to the day when I can un-cork a bottle of Wild Blueberry Cordial, put my feet up on the porch railing, and sip the dark blue, fruity drink while the sun sets over the lake.

Musselman and Wiggins have spent years researching edible plants and refining their recipes. Their experience and knowledge extends way beyond this fun, little guide book. I appreciate their wit and humor and their common-sense selections for easy-to-find wild edible plants. Perhaps they would like to take on Wild Edible Plants of Texas next?!—*Gwen Michele Thomas, Chapter Coordinator for the Society for Ecological Restoration's Texas Chapter, Texas Master Naturalist, and Botanical Research Institute of Texas Volunteer.*

DOS NUEVAS ESPECIES DE *GUADUA* PARA EL PERÚ (POACEAE: BAMBUSOIDEAE: BAMBUSEAE: GUADUINAE)

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RESUMEN

Se describen e ilustran dos especies nuevas de *Guadua* para el Perú afines a *Guadua angustifolia* Kunth: **Guadua lynnclarkiae** y **Guadua takahashiae** (Poaceae: Bambusoideae: Bambuseae: Guaduinae). Estas dos especies se reportan en el Noroccidente del Perú, en los departamentos de San Martín y Amazonas, en donde crecen a elevaciones entre 400 y 850 m. *Guadua lynnclarkiae* se caracteriza por que tiene los entrenudos de la porción media del culmo con longitudes que oscilan entre 40–50 cm de longitud, la yema de la región nodal conspicuamente pubescente y ciliada, lígula interna de la hoja caulinar arqueada en el centro, con presencia o no de setas orales, y presencia de aurículas fimbriadas falcadas-lanceoladas en la parte superior de la vaina foliar. *Guadua takahashiae* se diferencia de su congéneres por la combinación de los siguientes caracteres: poca presencia de espinas sobre los culmos, entrenudos de la porción media del culmo con longitudes que oscilan entre 20–34 cm longitud, yema de la región nodal glabrescente, hoja caulinar abaxialmente de color rosado café, con lígula interna caulinar horizontal, y presencia de fimbrias en la parte superior de la vaina foliar. Ninguna de las dos taxas se ha reportado en flor. Ambas son especies promisorias que pueden contribuir al desarrollo local y regional.

PALABRAS CLAVES: Poaceae, Bambusoideae, Guaduinae, *Guadua*, Perú

ABSTRACT

Guadua lynnclarkiae and **Guadua takahashiae,** two new species of woody bamboos from Peru, are described and illustrated. Both species are known from northwestern Peru, in San Martin and Amazonas departments, growing at 400 to 850 m in elevation. *Guadua lynnclarkiae* is characterized by 40 to 50 cm long internodes in the middle portion of the culm, the bud of the nodal region conspicuously pubescent and ciliate, the culm leaf inner ligule arching in the middle (with or without oral setae), and falcate-lanceolate auricles marginally fimbriate at the summit of the foliage leaf sheath. *Guadua takahashiae* is distinguishable from its congeners by the following combination of characters: sparsely thorny branches, the internodes of the middle portion of the culm 20 to 34 cm long, the bud of the nodal region glabrescent, the culm leaf abaxially pink-brownish in color, the culm leaf inner ligule horizontal, and bearing fimbria at the summit of the foliage leaf sheath. Flowering is unknown for both taxa. These two new species are potential useful bamboos for local and regional development.

KEY WORDS: Poaceae, Bambusoideae, Guaduinae, *Guadua*, Perú

INTRODUCCION

Guadua Kunth (Poaceae: Bambusoideae: Bambuseae: Guaduinae) es un género endémico de América y es el género tipo de la subtribu Guaduinae, la cual incluye además los géneros: *Apoclada, Eremocaulon, Otatea y Olmeca* (Soderstrom & Londoño 1987; Judziewicz et al. 1999; Londoño & Clark 2002; Ruiz-Sanchez et al. 2008). Estudios recientes basados en secuencias de ADN y en caracteres morfológicos (Kelchner et al. 2013; Bamboo Phylogeny Group 2012) ratifican que la subtribu Guaduinae pertenece al clado de los bambúes neotropicales leñosos y que conforma un linaje monofilético en el árbol evolutivo de los bambúes. Esta subtribu se caracteriza por tener una micro morfología de la lamina foliar inusual, en donde la lamina posee estomas en ambas superficies (amfiestomática) rodeados por papilas, carácter que se observa principalmente en la superficie adaxial (Soderstrom & Ellis 1987; Ruiz-Sanchez et al. 2008); además, la lamina foliar de las especies de Guaduinae carece de esclerenquima intercostal y tiene la típica nervadura central compleja de la mayoría de los bambúes leñosos (Bamboo Phylogeny Group 2012; Soderstrom & Ellis 1987).

Guadua reúne 29 especies, de las cuales 17 taxas han sido descritas en los últimos 20 años. La región amazónica de Brasil, Perú, Bolivia, Ecuador, Colombia y Venezuela se considera el centro de origen de este género, con una alta diversidad de especies (Judziewicz et al. 1999; Londoño & Peterson 1992).

Perú es uno de los países Andinos con mayor riqueza en diversidad de bambúes. Según el inventario de

bambúes realizado por Londoño (2002) para América Latina y en particular para el Perú, se reportaron 37 especies y 8 géneros. Los departamentos de Pasco y del Cuzco son los que albergan la mayor diversidad, mientras que los departamentos de Madre de Dios y del Amazonas son los que presentan la mayor área cubierta por bambúes (Takahashi & Ascencios 2004). Ancestralmente el bambú ha sido utilizado por comunidades nativas y rurales del Perú, desde las tierras altas de los Andes hasta las tierras bajas de la región amazónica (Tovar 1993) y se utiliza en una cantidad proporcionalmente menor que otros materiales que usan para la construcción, siendo los usos más frecuentes techos, cercos, paredes, y como elemento decorativo de viviendas y locales comerciales, sin cumplir realmente un papel estructural (Takahashi & Ascencios 2004).

Un viaje de colección por los departamentos de San Martín y Amazonas, en el noroccidente del Perú, ha revelado dos nuevas especies de *Guadua* relacionadas con *Guadua angustifolia* Kunth, las cuales reúnen una serie de características como son el gran tamaño, rectitud del culmo y espesor de pared mayor a 1.5 cm, lo que las convierte en especies promisorias para el desarrollo local y regional en sectores como la construcción e industrialización.

Se examinaron especímenes en herbarios nacionales e internacionales (K, ISC, MOL, MO, USM, US) pero no se encontraron materiales en flor de estas especies. Se conoce que la longitud del ciclo de floración de los bambúes tropicales varía en cada especie, con un rango de fluctuación entre 3–60 años. Ante la evidencia de caracteres morfológicos vegetativos únicos en estas nuevas especies se toma la decisión de describirlas sin flor.

La importancia económica de las especies afines a *Guadua angustifolia* Kunth obliga a utilizar caracteres macromorfológicos, fáciles de visualizar por parte de los interesados con el fin de que se logre una pronta identificación, por eso se hace énfasis en estructuras morfológicas como rizoma, culmo, hoja caulinar, yema de la región nodal y ramificación. La estructura morfológica denominada hoja caulinar es una importante fuente de caracteres para diferenciar las especies del género *Guadua* y siempre debe ser recolectada; el tamaño e indumento de la hoja caulinar, la proporción en tamaño entre la vaina y la lámina caulinar, la forma y tamaño de la lígula, son de relevancia para la identificación de las especies de este género.

La siguiente clave diferencia las dos nuevas especies de *Guadua* de la especie tipo *Guadua angustifolia* Kunth, que ocurren en el noroccidente del Perú.

1. Hoja caulinar de color café rosado cuando joven; lígula de la hoja caulinar casi recta; yema glabrescente; pseudopeciolo por la superficie adaxial puberuloso _____ **Guadua takahashiae**
1. Hoja caulinar de color café cuando joven; lígula de la hoja caulinar arquedad en el medio; yema pubescente ; pseudopeciolo por la superficie adaxial glabro.
   2. Hoja caulinar sin setas orales. Lámina foliar 6–20 cm de longitud por 0.5–2 cm ancho, sin aurículas, presencia de fimbrias en la parte superior de la vaina foliar _____ **G. angustifolia**
   2. Hoja caulinar con setas orales. Lámina foliar (15–)18–23 cm de longitud por 1.6–4.2 cm ancho; aurículas fimbriadas falcado-lanceoladas en la parte superior de la vaina foliar _____ **G. lynnclarkiae**

Guadua lynnclarkiae Londoño, sp. nov. (**Fig. 1**). TYPE: PERU. San Martin. Provincia Moyobamba, Distrito Moyobamba, Comunidad de Atumplaya, 5°50'48.9"S, 77°14'52.2"W, 833 m, 8 May 2010, *X. Londoño, H. Panduro & G. Guerreo 1045* (HOLOTIPO: MOL!; ISOTIPOS: COL, CUVC, ISC, US).

Woody, thorny bamboo. Rhizomes pachymorph, turtle-like form. Culm (18–)20–27 m tall, (6–)9–17 cm diameter, green, erect below and arching apically; internodes (15–)30–49 cm long, hollow, the wall 2–5 cm thick. Culm leaves coriaceous, deciduous, brown, the blade 5 to 6 times shorter than the sheath; sheath 57–77 cm long, 68–72 cm wide; blade 11–14 cm long, 13–15 cm wide, persistent; inner ligule 2–3 mm long, curved in the middle and ending before the culm leaves margins, densely ciliolate, sometimes developing oral setae. Branching intravaginal; primary branch solitary and armed. Foliage leaves 10–12 per complement; sheath glabrescent, bearing (or not) falcate-lanceolate auricles at the summit, the overlapping margin ciliate; pseudopetioles 5–8 mm long; blade (15–)18–23 cm per (1.6–)2–4.2 cm wide, L:W 5–8:1, lanceolate to linear-lanceolate, the midnerve and primary nerves prominent and yellow along the blade.

Bambú leñoso y espinoso. Rizoma paquimorfo, en forma de tortuga, cuerpo del rizoma 20–40 cm longitud; entrenudos apicales 2.5 a 3 cm longitud, entrenudos basales 1.2–1.3 cm longitud; raíces de soporte 3 a 4 a cada lado del rizoma, con diámetros 8–10 cm por raíz de soporte; raíces adventicias amarillo naranja, 0.5–0.7 cm diámetro. **Culmo** (18–)20–27 m de altura, (6–)9–17 cm diámetro, erecto en la base y arqueado apicalmente, de color verde con rayas verdes más oscuras cuando joven, pubescente en el ⅓ superior; **entrenudos** huecos, (15–)30–49 cm longitud, espesor de la pared 2–5 cm; **nudo** solitario, línea nodal horizontal, pronunciada,

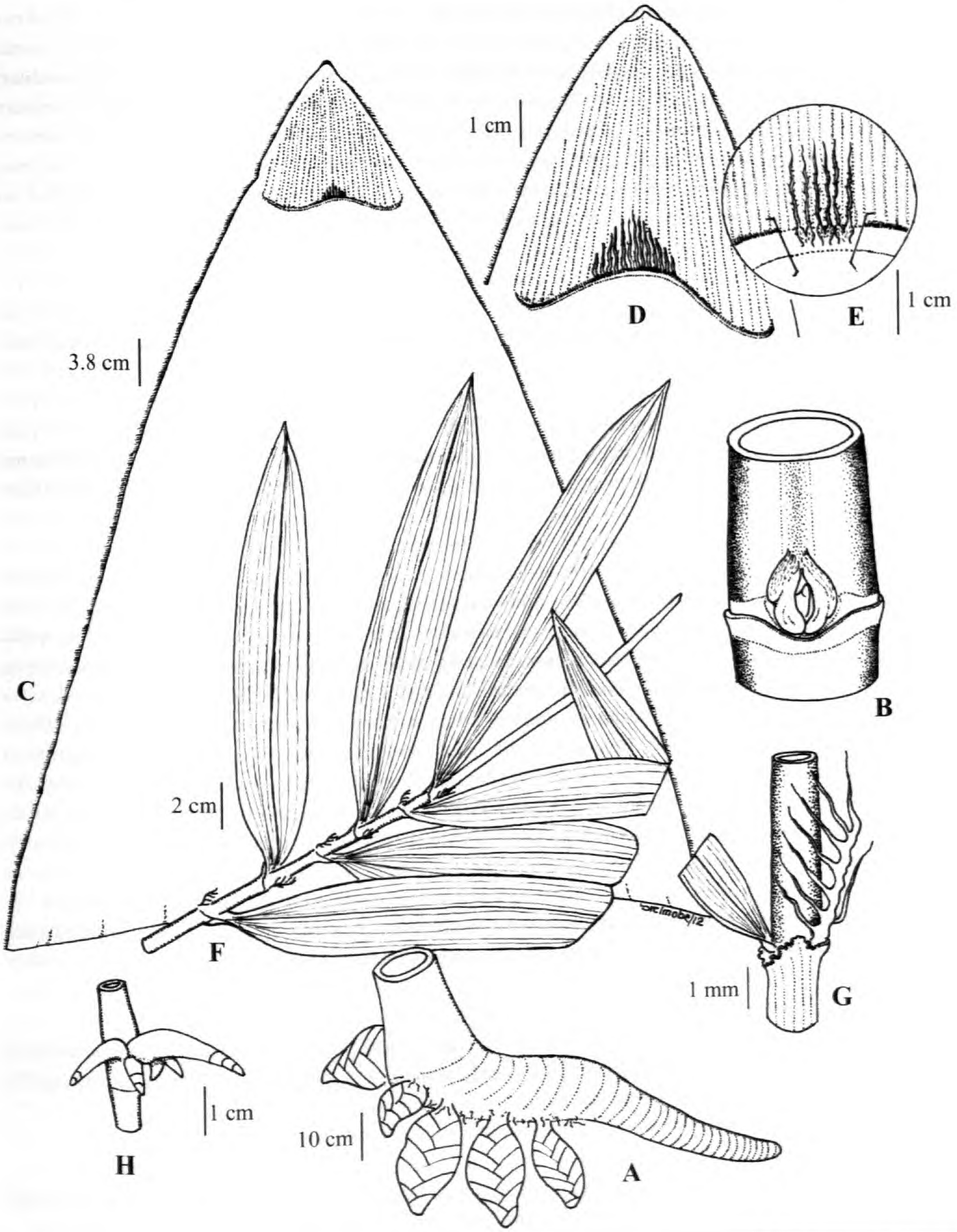


Fig. 1. *Guadua lynnclarkiae*. **A.** Rizoma paquimorfo con raíces de soporte gruesas. **B.** Región nodal con yema solitaria. **C.** Hoja caulinar, vista adaxial. **D.** Detalle de la lámina caulinar mostrando lígula interna y setas orales, vista adaxial. **E.** Detalle de la parte basal de las setas orales. **F.** Complemento foliar. **G.** Detalle de la región apical de la vaina foliar, vista abaxial. **H.** Nudo con espinas. (C–G, *Londoño et al. 1045*, COL; H, *Londoño et al. 1044*, COL; A y B, basados en fotos de X. Londoño, rodal Comunidad de Atumplaya. Ilustración por Miryam Monsalve B.

ligeramente inclinada por debajo de la yema, con banda de pelos blancos, adpresos, arriba y abajo de la línea nodal: banda superior 0.4–0.6 cm, banda inferior 1.2–1.5 cm; **yema** solitaria, ampliamente triangular, profilo pubescente, obtuso hacia el ápice, cubierto por pelos adpresos de color café, márgenes ciliados. **Hoja caulinar** triangular, 68–91 cm de longitud por 68–72 cm de ancho, coriácea, de color café, decidua, lámina 5 a 6 veces más pequeña que la vaina; **vaina** 57–77 cm de longitud por 68–72 cm de ancho, abaxialmente hispida, cubierta por dos tipos de pubescencia: a) pelos ondulados, aproximadamente 1 mm de longitud, hialinos, retrorsos, adpresos, y b) pelos hispidos, rígidos, 2–2.5 mm, cafés, removibles, márgenes conspicuamente ciliadas con raya marginal oscura, cilios café pardo, aproximadamente 5 mm longitud, superficie adaxial glabra, brillante; **lígula interna** 2–3 mm de longitud, truncada, arqueada en el centro y prolongándose ligeramente por un lado, termina antes de la margen en ambos extremos, adaxialmente glabra, abaxialmente pubescente, margen densamente ciliolado, cilios hialinos, cortos, aproximadamente 0.2–0.3 mm de longitud, con o sin desarrollo de setas orales en la parte media de la lígula en número de (4–)10–42; **setas orales** 1.5–2.7 cm longitud, basalmente redondeadas, escábridas, oscuras, y rectas, luego ligeramente onduladas y pajizas; **lámina** 11–14 cm de longitud, 13–15 cm de ancho, triangular, erecta, persistente, abombada, ápice mucronado, mucrón fuerte, aproximadamente 1 mm de longitud, cuando se rompe se divide en 2 o 3 partes, si son 3 una central más ancha y dos laterales más delgadas, superficie abaxial glabrescente, superficie adaxial pubescente, nervada, cubierta por pelos café claro entre las nervaduras, márgenes ciliados, cilios aproximadamente 4 mm longitud. **Ramificación** intravaginal; rama primaria solitaria y con espinas, con 1–4(–5) espinas por nudo, rama espinosa con o sin desarrollo de complementos foliares en el extremo; sin desarrollo de ramificaciones en el ⅓ medio del culmo. **Hojas del Follaje** 10–12 por complemento, dimórficas, las del ⅓ basal del culmo con laminas foliares anchas (hasta 4 cm) y con presencia de aurículas fimbriadas en la parte superior de la vaina, los del ⅓ apical con láminas foliares menos anchas (hasta 2.5 cm), con o sin presencia de aurículas fimbriadas sobre la vaina; **vaina** adaxialmente glabrescente, con aurículas falcadas-lanceoladas y/o fimbrias en la parte superior, márgenes ciliados, evidentemente más oscuros, cilios 0.5–1 mm de longitud, usualmente hialinos; aurículas falcadas-lanceoladas, 5–8 mm de longitud por 0.5 mm de ancho, verde o purpura, pubescentes, con las márgenes fimbriadas; fimbrias de color blanco-marfil, ligeramente onduladas, basalmente escábridas, 6–12 mm de longitud; **lígula interna** aproximadamente 0.5 mm, truncada, densamente pubescente, blancuzca, margen conspicuamente ciliolado, cilios cortos, blanquecinos; **lígula externa** aproximadamente 0.5 mm de longitud, glabra, brillante, finamente ciliolada a lisa; **pseudopeciolo** 5–8 mm de longitud, adaxialmente glabro, abaxialmente glabrescente, pulvinado, pulvino piloso, de color pajizo a café; **lámina** (15–)18–23 cm por (1.6–)2–4.2 cm de ancho, L:W = 5–8:1, 17–20 nervaduras, lanceolada a linear-lanceolada, adaxialmente glabra, raramente con tricomas estrigosos esparcidos, transparentes, tricomas café-rojizo en la base, con 3–4 nervios submarginales escábridos, abaxialmente glabra, papilosa, teselada, nervadura central y nervios primarios amarillos y prominentes en toda la longitud de la lámina, un margen escábrido, el otro escabrídulos, ápice acuminado, con mucrón retorcido, 3–4 mm longitud. **Inflorescencia** no vista.

Etimologia.—Esta especie se nombra en honor de Lynn G. Clark (Iowa State University), líder mundial en el estudio de los bambúes de América, quien ha dedicado gran parte de su vida a recolectarlos e investigarlos, realizando aportes invaluables a su conocimiento.

Distribución y habitat.—Se distribuye en el noroccidente del Perú, en el Departamento de San Martín, entre 800 y 900 m, a orilla de ríos y quebradas. No tolera áreas inundables. Quedan muy pocas poblaciones debido a la severa destrucción de la selva con fines agrícolas. Crece asociada en el sotobosque con heliconias, piperaceas, araceas, convolvulaceas, *Costus* sp., ciperáceas, melastomatáceas, ciclantáceas, helechos, iracas y gramíneas, y en el estrato superior con árboles del género *Ficus* sp. (higuerón u ojé).

Nombre común.—"Marona," y al rodal "Maronal."

Usos.—Se observa poco uso de este bambú en el área donde crece quizás debido a la abundancia de madera en la zona. Se utiliza para colocar antenas de TV, en la construcción de los techos con zinc, y para extraer "esterilla" o guadua picada para paredes y corrales. Su gran tamaño sumado al espesor de su pared (2 a 5 cm) y a sus propiedades físico-mecánicas hacen que esta especie tenga un gran potencial para la industria de la construcción y de los laminados.

Productividad.—Presenta alta densidad de culmos por hectárea (7000 culmos/ha) y una alta tasa de crecimiento, lo cual se corrobora con mediciones de culmos hasta de 15 cm de diámetro y 25 culmos por sitio en una planta con cinco (5) años de cultivo. Tuesta Vásquez (com. pers.), morador de Atumplaya, asegura que *Guadua lynnclarkiae* florece y no se muere.

Afinidades.—*Guadua lynnclarkiae* es similar a *Guadua angustifolia* Kunth. Esta dos especies comparten los siguientes caracteres: a) culmos de gran porte, con alturas hasta de 27 metros y diámetros superiores a 15 cm; b) región nodal con la banda inferior ligeramente más ancha que la superior; c) Hoja caulinar coriácea, de color café; d) lígula interna de la vaina foliar arqueada en el centro y ligeramente prolongada por un lado, finalizando antes de las márgenes en ambos extremos; e) yema de la región nodal cubierta por un profilo pubescente de color café; y f) rama primaria solitaria, con 1– 5 espinas por nudo. Sin embargo, *Guadua lynnclarkiae* se diferencia de *G. angustifolia* por tener (a) rizomas paquimorfos con raíces de soporte gruesas, en número de 3–4 a cada lado, que le proveen al rizoma una apariencia de tortuga vs. raíces de soporte delgadas, en número de 4–8 a cada lado, que le proveen al rizoma una apariencia de lagarto; (b) entrenudos de los culmos ligeramente más largos, 15–49 cm vs. 14–34 cm; (c) culmos con espesor de la pared de 2–5 cm vs. 1–3 cm; (d) presencia o no de setas orales en la parte media de la lígula caulinar vs. no presenta setas orales; (e) lamina foliar de mayor tamaño, 15–23 cm de longitud por 1.6–4.2 cm de ancho vs. 6–20 cm de longitud por 0.5–2 cm de ancho; (f) vaina foliar con aurículas falcadas-lanceoladas y/o fimbrias en la parte superior de la vaina vs. solo fimbrias; (g) pseudopeciolo glabrescente, con pulvino piloso vs. pseudopeciolo glabro, con pulvino glabro (Tabla 1).

La presencia de setas orales en la lígula de la hoja caulinar es frecuente en la subtribu Guaduinae, observándose en géneros como *Eremocaulon*, *Olmeca* y *Otatea* (Londoño & Clark 2002; Ruiz-Sanchez et al. 2011; Judziewicz et al. 1999) sin embargo no se había reportado para el género *Guadua* como lo mencionan Ruiz-Sanchez et al. (2008; 2011). *Guadua lynnclarkiae* puede desarrollar setas orales en la parte media de la lígula caulinar, de 1.5 a 2.7 cm longitud, de color pajizo y conspicuamente escábridas basalmente. Estas setas orales no se ajustan exactamente a la definición dada por Clark & Cortés (2004) quienes las definen como una estructura ubicada en el área de la lígula, entre la lígula interna y la lámina, en la boca de la vaina de la hoja caulinar, usualmente planas y anchas, con tamaños hasta 7 cm de longitud por 0.2 a 1.2 mm de diámetro, y con la base adherida a la superficie abaxial de la lígula interna. Las setas orales en *Guadua lynnclarkiae* no son planas como en *Otatea* y *Eremocaulon* (Ruiz-Sanchez et al. 2010; Soderstrom & Londoño 1987): son redondeadas y muy escábridas basalmente, con una apariencia más de fimbria que de seta pero por su ubicación en la boca de la vaina caulinar y en la mitad de la lígula internase describen como setas orales.

Las plántulas (chusquines) de *Guadua lynnclarkiae* desarrollan además de laminas foliares anchas, aurículas fimbriadas en la parte superior de la vaina foliar, estos dos caracteres sirven para diferenciar en fase de vivero *G. lynnclarkiae* de *G. angustifolia* Kunth (láminas foliares más angostas, presencia de fimbrias y sin aurículas). Las plantas en estado adulto de *G. lynnclarkiae* no siempre conservan el carácter de las aurículas fimbriadas en la parte superior de la vaina foliar: es posible observar en un mismo complemento foliar vainas con y sin aurículas fimbriadas.

Otros ejemplares examinados: **PERÚ. San Martín:** Provincia Rioja, Distrito San Fernando, Sector Boca del Río Soritor, 5°52'56.4"S; 77°15'8.7"W, 420 m, 7 May 2010, *X. Londoño, J. Takahashi & H. Panduro 1044* (CUVC, ISC, MOL); Provincia Moyobamba, Distrito Moyobamba, Comunidad Atumplaya, 5°50'48.9"S; 77°14'52.2"W, 883 m, Feb 2001, *N. Ocean* s.n. (CUVC, MOL); Atumplaya, 13 Mar 1999, *G. Rengifo-Ruiz 01* y 02 (CUVC, MOL).

Guadua takahashiae Londoño, sp. nov. (**Fig. 2**). TIPO: PERU. AMAZONAS: Provincia Bagua, Distrito Aramango, aprox. 1 km vía Aramango - El Muyo, 5°24'51.9"S; 78°26'37.5"W, 456 m, 6 May 2010, *X. Londoño, J. Takahashi & H. Panduro 1043* (HOLOTIPO: MOL!; ISOTIPOS: COL, CUVC, ISC, US).

Woody, thorny bamboo. Rhizomes pachymorph, lizard-like form. Culm 12–15(–20) m tall, (7–)9–14 cm diameter, green, erect below and arching apically; internodes (10–)17–34 cm long, hollow, the wall 1.5–2.5 cm thick. Culm leaves coriaceous, deciduous, pink-brownish, the blade 6 to 7 times shorter than the sheath; sheath 56–66 cm long per 57–60 cm wide; blade 9–10 cm long per 8–10 cm wide, persistent; inner ligule 1–2 mm long, horizontal, densely ciliolate along the margin and ending before the culm leaf margins. Branching intravaginal; primary branch solitary. Foliage leaves 6–10 per complement; sheath glabrous, fimbriate at the summit, the overlapping margin minutely ciliolate; pseudopetiole (2–) 3–5 mm long; blade (8–)14–16(–18) cm long per (0.8–)1–1.5 cm wide, L:W 7–19:1, linear-lanceolate, the midnerve prominent and yellow.

Tabla 1. Comparación de los caracteres vegetativos de *Guadua lynnclarkiae, G. takahashiae* y *G. angustifolia.*

	Guadua lynnclarkie	*G. takahashiae*	*G. angustifolia*
Culmo			
altura (m) x diámetro (cm)	18–27 × 6–17	12–15(–20) × (7–)9–14	18–27 × (7–)10–13(–23)
entrenudos (cm)	(15–)30–49	(10–)17–34	(14–)20–34
espesor pared (cm)	2–5	1.5–2.5	1–3
Región Nodal			
Banda superior (cm)	0.4–0.6 cm	0.6–0.8(–1)	(0.7–)1–1.2
Banda inferior (cm)	1.2–1.5 cm	1.2–1.4(–1.8)	(1.3–)1.5–2
Yema			
Profilo	pubescente	glabrescente	pubescente
Hoja Caulinar			
Tamaño (largo x ancho) (cm)	68–91 × 68–72	60–75 × 55–60	27–68 × 30–75
Color	café	café rosado	café
tamaño lígula interna (mm)	2–3	1–2	1–2.5
forma lígula interna	arqueada en el centro y finalizando antes de las márgenes	recta, finaliza antes de las márgenes	arqueada en el centro y finaliza antes de las márgenes
Ramificación			
No. Espinas/nudo	1–4(–5)	1–3	1–3(–5)
Hojas del Follaje			
Tamaño lámina (cm)	(15–)18–23 × 1.6–4.2	(8–)14–18 × 0.8–1.5	6–20 × 0.5–2
L:W	5–8:1	7–19:1	6–15:1
Aurícula vaina foliar	falcada-lanceolada	ausente	ausente
Pseudopeciolo			
longitud (mm)	5–8	3–5	4–6(–8)
superficie adaxial	glabro	puberuloso	glabro
superficie abaxial	glabrescente	glabro	glabro
Indumento del pulvinulo	piloso	glabrescente	glabro

Bambú leñoso y espinoso. Rizoma paquimorfo en forma de lagarto, cuerpo del rizoma 50–60 cm de longitud, entrenudos apicales 2.5–3 cm de longitud, entrenudos basales 1.5–2 cm de longitud; 5–6 raíces de soporte a cada lado del rizoma, con diámetros 5–6 cm por raíz de soporte, raíces adventicias de color amarillento. **Culmo** 12–15 (–20) m de altura, (7–) 9–14 cm diámetro, erecto en la base y arqueado apicalmente, de color verde con rayas verdes más oscuras cuando joven, tempranamente se torna verde–grisáceo, no desarrolla ramas con espinas en el ⅓ basal, desarrolla una espina corta, gruesa y adpresa sobre los entrenudos del ⅓ medio del culmo; **entrenudos** huecos, (10–)17–34 cm longitud, espesor de la pared 1.5–2.5 cm; **nudo** solitario, línea nodal horizontal, pronunciada, ligeramente inclinada por debajo de la yema, con banda de pelos blancos, adpresos, arriba y abajo de la línea nodal: banda superior 0.6–0.8(–1) cm, banda inferior 1.2–1.4(–1.8) cm; **yema** solitaria, triangular a triangular-apiculada, protegida por profilo con márgenes envolventes glabrescentes, de color rosado cuando joven, alas del profilo pubescente, cubiertas por pelos adpresos de color café claro, marginalmente ciliadas, cilios café-pajizo. **Hoja caulinar** triangular, 60–75 cm de longitud por 55–60 cm de ancho, coriácea, de color café rosado, decidua, lámina 6 a 7 veces más pequeña que la vaina; **vaina** 56–66 cm de longitud por 57–60 cm de ancho, abaxialmente híspida, cubierta por tres tipos de tricomas: a) tricomas cortos, escábridos, rígidos, 0.3–1 mm de longitud, café-hialino, b) tricomas híspidos, largos, rígidos, fácilmente desprendibles, 2–3 mm de longitud, café-hialino y c) tricomas cortos, finos, ondulados, blanquecinos, retrorsos, hasta 0.5 mm de longitud, márgenes ciliados, cilios fácilmente deciduos, hialinos-pajizos, superficie adaxial glabra, brillante; **lígula interna** 1–2 mm de longitud, truncada, horizontal, irregular, con pequeñas invaginaciones hacia los extremos, termina antes de la margen en ambos lados, adaxialmente glabra, abaxialmente pubescente, cubierta por tricomas hialinos-pajizos, margen ciliolado, cilios hialinos, cortos, aproximadamente 0.2 mm longitud; **lámina** 9–10 cm de longitud por 8–10 cm de ancho, triangular, erecta, persistente, ligeramente abombada,

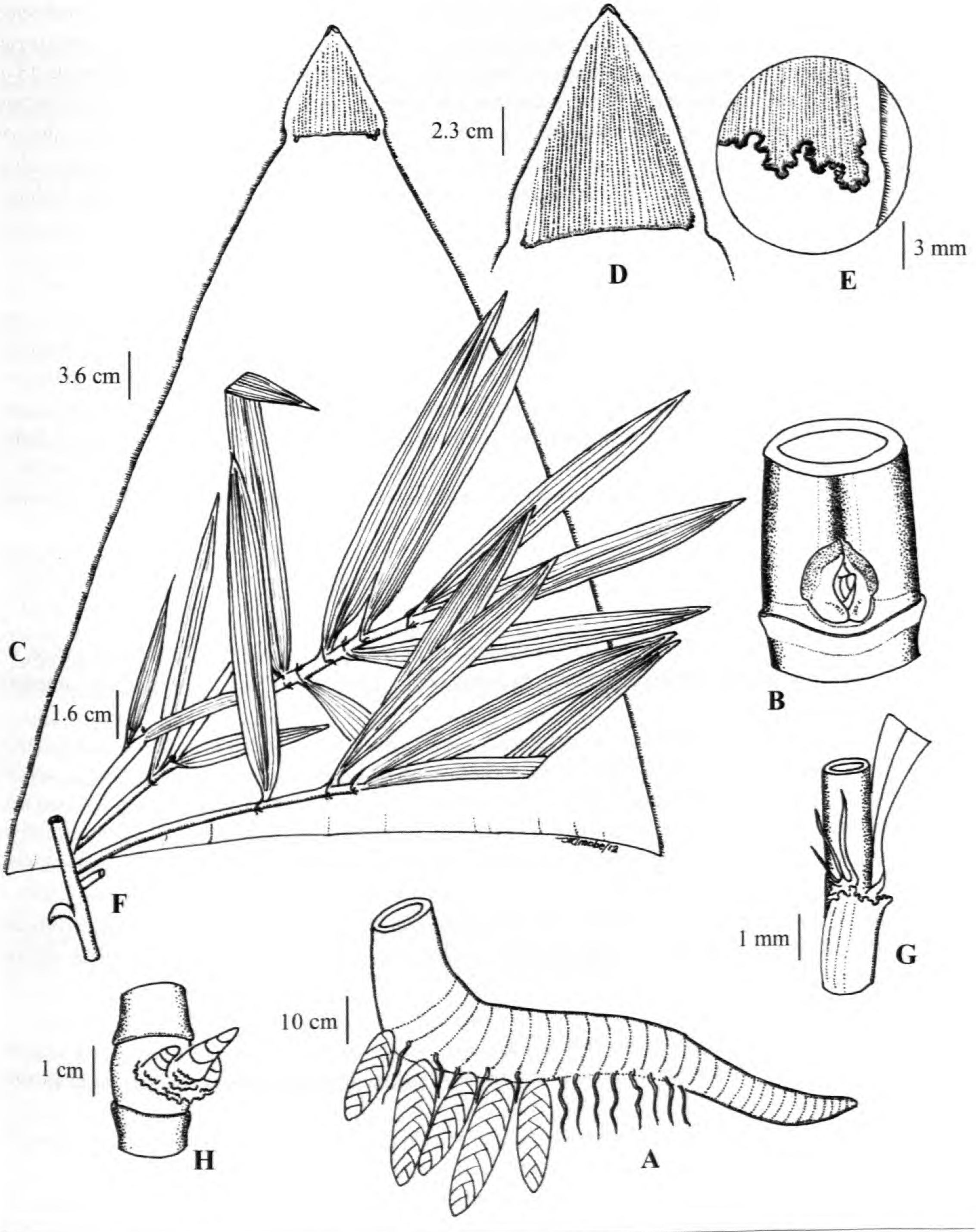


Fig. 2. *Guadua takahashiae*. **A.** Rizoma paquimorfo con raíces de soporte delgadas. **B.** Región nodal con yema solitaria. **C.** Hoja caulinar, vista adaxial. **D.** Detalle de la lámina caulinar mostrando lígula interna. **E.** Detalle de la lígula interna, mostrando invaginaciones hacia los extremos. **F.** Ramificación en región nodal de la porción apical y complementos foliares. **G.** Detalle de la región apical de la vaina foliar, vista abaxial. **H.** Nudo con espinas. (C–G, *Londoño et al. 1043*, COL; H, *Londoño et al. 1042*; A, basado en fotos de J. Takahashi, rodal Distrito Aramango; B. basado en fotos de X. Londoño, rodal El Muyo. Ilustración por Miryam Monsalve B.).

ápice mucronado, mucrón frágil, aproximadamente 1 mm de longitud, cuando se rompe se divide usualmente en 2 partes, superficie abaxial glabrescente, superficie adaxial pubescente, nervada, densamente cubierta por pelos café claro entre las nervaduras, márgenes ciliados, cilios fácilmente deciduos, aproximadamente 0.5–1 mm de longitud. **Ramificación** intravaginal; rama primaria solitaria, sin espinas o con espinas inconspicuas en número de 1–3 por nudo. **Hojas del Follaje** 6–10 por complemento, linear-lanceoladas; **vaina** abaxialmente glabra, estriada, brillante, con fimbrias en la parte superior de la vaina, márgenes finamente ciliolados, cilios hialinos, 0.05–0.1 mm de longitud; fimbrias basalmente escábridas, pajizas, apicalmente onduladas, hialinas, 3–7 (–14) mm de longitud; **lígula interna** 0.2–0.3 mm, truncada, glabra, margen finamente ciliolado, cilios hialinos; **lígula externa** 0.1–0.2 mm de longitud, glabra, brillante, finamente ciliolada; **pseudopeciolo** (2–)3–5 mm de longitud, adaxialmente puberuloso, abaxialmente glabro, pulvinado, pulvino glabrescente, brillante, pajizo; **lámina** (8–)14–16(–18) cm de longitud por (0.8–)1–1.5 cm de ancho, L:W = 7–19:1, 9–13 nervaduras, linear-lanceolada, adaxialmente con pelos estrigosos, esparcidos, hialinos, antrorsos, hasta 1mm de longitud, con 3–4 nervios submarginales escábridos, abaxialmente con pelos estrigosos esparcidos, hialinos, antrorsos, hasta 1 mm de longitud, densamente papilosa, teselada, nervadura central prominente, amarilla, un margen escábrido, otro finamente aserrado, ápice acuminado, termina en mucrón recto, 1.5–3 mm de longitud. **Inflorescencia** no vista.

Etimología.—Esta especie hace honor a Josefina Takahashi (Asociación Peruana del Bambú), líder en el conocimiento, promoción y desarrollo del bambú en el Perú.

Distribución y hábitat.—Ocurre en el noroccidente del Perú, en el Departamento de Amazonas, entre 400 y 600 msnm, donde se observa a orilla de ríos y quebradas o en zona de laderas.

Nombre común.—Guayaquil.

Usos.—Se utiliza en la construcción, para la elaboración de entrepisos, paredes de bahareque, techos, vigas, y en la construcción de infraestructura agropecuaria como cercos, gallineros, y corrales para animales menores.

Afinidades.—*Guadua takahashiae* comparte con *Guadua angustifolia* y *Guadua lynnclarkiae* la hoja caulinar triangular, coriácea, con la lígula caulinar finalizando antes de las márgenes, la yema de la región nodal protegida por un profilo corto y el desarrollo de una rama por nudo. *Guadua takahashiae* es más cercana a *G. angustifolia*, con quien comparte la longitud de los entrenudos (10–34 cm), el espesor de la pared del culmo (1.5–2.5 cm), la forma triangular y el tamaño del profilo, la forma linear-lanceolada de la lámina foliar, la presencia de tricomas estrigosos, transparentes, antrorsos, esparcidos por ambas superficies de la lamina foliar y la presencia de fimbrias en la parte superior de la vaina foliar. *Guadua takahshiae* difiere de *G. angustifolia* por tener: (1) escasa presencia de espinas sobre el culmo y sobre el follaje vs. abundante presencia; (2) espinas cuando presentes en número de 1–3 por nudo vs. 1–5 por nudo; (3) profilo de la yema nodal glabrescente, pigmentado de rosado vs. pubescente, de color café; (4) hoja caulinar de color café rosado vs. café; (4) superficie abaxial de la hoja caulinar con baja concentración de pelos híspidos, largos, de color café-hialino en la región dorsal y basal vs. alta concentración de pelos de color café; (5) lígula interna de la hoja caulinar horizontal vs. arqueada en el centro (Tabla 1).

A pesar de que *G. takahashiae* comparte el color café rosado de la hoja caulinar con *Guadua chacoensis*, se diferencia de esta por el desarrollo de: a) una sola rama por nudo vs. 1 principal + 2 laterales posteriormente; ausencia de ramas con espinas en la porción basal del culmo vs. presencia; profilo pequeño con márgenes envolventes glabrescentes, de color rosado cuando joven y alas del profilo pubescente vs. profilo grande con márgenes envolventes conspicuamente pubescentes, de color café cuando joven y alas del profilo densamente pubescentes. La forma recta y casi tubular de las primeras ⅔ partes del culmo, y la ausencia de ramas con espinas sobre el culmo hacen que *Guadua takahashiae* sea una especie ideal para cultivar y explotar sosteniblemente, con un gran potencial para la industria de la construcción.

Otros ejemplares examinados: **PERU**. **Amazonas:** Provincia Bagua, Distrito Aramango, El Muyo, 5°24'56.3"S; 78°27'16.5"W, 440 m, 6 May 2010, *X. Londoño, J. Takahashi & H. Panduro 1042* (MOL, COL, CUVC, ISC).

AGRADECIMIENTOS

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BOOK REVIEW

PATRICIA FOLLEY. 2011. **The Guide to Oklahoma Wildflowers.** (ISBN: 978-1-60938-046-5, pbk). University of Iowa Press, 119 West Park Road, 100 Kuhl House, Iowa City, Iowa 52242-1000, U.S.A. (**Orders:** www.uiowapress.org, 1-800-621-2736). $39.95, 312 pp., 415 color photos, 1 color map, 6" × 9".

With permission from Great Plains Research 23(1):81–82. 2013

Oklahoma is a beautiful state and home to some 2,500 species of flowering plants. Patricia Folley has captured in full color some 200 striking and beautiful wildflowers. From the state wildflower (*Gaillardia pulchella*) to the state grass (*Sorghastrum nutans*), this wildflower guide covers plants growing in the Rocky Mountain foothills in the northwest to the cypress swamps of the southeast and a lot in between.

Each species is illustrated with at least two photos, showing the habit and a close-up of the flower. Text wise, there is a short description, followed by the geographic area of the state where the species grows, flowering time, and typical habitat. Common and scientific names are provided but not the family name. The organization of the book is taxonomic with monocots first then followed by dicots with families (not noted) and genera in phylogenetic order. This arrangement is difficult to follow for the nonbotanist. It would seem an organization by flower color would have made using the book for identification purposes much easier. The color index in the back of the book is organized into four color groups and then alphabetical by common name. So unless you know the common name, finding your plant by flower color can take time.

As a native Oklahoman, I was disappointed to not find the state tree of Oklahoma (redbud, *Cercis canadensis*) included. Surely the redbud—with its mass of striking pink flowers—is more colorful and noticeable than *Juncus marginatus* (grassleaf rush). I looked hard but also failed to find the state floral emblem, the mistletoe (*Phoradendron serotinum*).

But if you love wildflowers, and Oklahoma ones at that, then you'll find *The Guide to Oklahoma Wildflowers* worthwhile to have in your library and perhaps a second copy in your automobile.—*Barney Lipscomb, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

CALATHEA CROATII (MARANTACEAE), A NEW ENDEMIC SPECIES FROM PANAMA

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ABSTRACT

Calathea croatii H. Kenn., endemic to Panama, is described as new for inclusion in Flora Mesoamericana. It occurs in montane wet to cloud forest habitat and is only known from one collection each from Prov. Chirquí, Com. Ngäbe-Buglé and Prov. Coclé. It shares a similar habit, leaf venation and inflorescence morphology with the closely related *C. guzmanioides* L.B. Sm. & Idrobo. *Calathea croatii* differs from *C. guzmanioides* in the glabrous vs. tomentose major veins of the adaxial leaf surface and the bracts ovate to narrowly ovate with apex acute vs. broadly ovate to broadly elliptic with broadly obtuse to rounded apex (bract length to width ratios 2.62–2.75 vs. 0.95–1.78:1).

RESUMEN

Calathea croatii H. Kenn., endémica de Panamá, se describe como nueva para incluirla en la Flora Mesoamericana. Ésta ocurre en el bosque montano muy húmedo y bosque nuboso (nefosilva); solo conocida de una colección de la Prov. Chiriquí y a Com Ngäbe-Buglé & Prov. Coclé. Está estrechamente relacionada con *C. guzmanioides* L.B. Sm. & Idrobo y comparte un hábito similar, venación de la hoja, y morfología de inflorescencia. *Calathea croatii* se distingue de *C. guzmanioides* por las venas principales glabras vs. tomentosas en la superficie adaxial de las hojas y las brácteas de ovadas a angostamente ovadas con el ápice agudo vs. anchamente ovado a anchamente elíptico con el ápice de anchamente obtuso a redondeado (la relación largo /ancho de las brácteas 2.62–2.75 vs. 0.95–1.78:1).

In preparation for the Flora Mesoamericana treatment, the species of Marantaceae from Panama has been a special focus. With considerably more collecting since publication of the Woodson and Schery (1945) treatment for Flora of Panama, listing 23 species, the total has more than doubled. Besides field work, recent herbarium studies at Missouri Botanical Garden and University of Panama have uncovered addition new species. Currently, a total of 67 species are recognized (ca. 191 per cent increase from the original Flora of Panama treatment). Seventeen species are recognized as endemic, including the one described herein plus two as yet undescribed taxa.

TAXONOMIC TREATMENT

Calathea croatii H. Kenn., sp. nov. (**Figs. 1, 2**). TYPE: PANAMÁ. CHIRIQUÍ: along road between Gualaca and Chiriquí Grande, 5.9 mi beyond Los Planes de Hornito (in direction of Lake), 4.8 mi beyond turnoff to Caldera, 1225 m, 08°45'N, 82°14'W, 19 Sep 1987, *T.B. Croat 67776* (HOLOTYPE: MO).

Calathea croatii differs from the most closely related species, *C. guzmanioides*, by the glabrous vs. tomentose major veins of the abaxial leaf surface, the bracts ovate to narrowly ovate with apex acute vs. broadly ovate to broadly elliptic with apex broadly obtuse to rounded (bract length to width ratios 2.62–2.75 vs. 0.95–1.78:1).

Plants rhizomatous, caulescent herbs, 1.5–2.05 m; cataphylls narrowly ovate, red-purple; stem dark purple just below subtending leaf, the rest green, appressed tomentose, hairs 0.5–1 mm. **Leaves** 2–4 basal with a single cauline leaf, rarely 2, borne above an elongate stem internode, ca. 0.9 m; leaf sheath often auriculate, wings (margins) dying back in age, often tearing away from central portion, wings apically red-purple, appressed tomentose, hairs 0.5–1 mm, central back portion green in upper 10–15 cm, red-purple basally, appressed tomentose on wings, hairs 0.5–1 mm, 15.7–24 cm in subtending leaf, 58–73 cm in basal leaves; petiole bearing a narrow groove adaxially, green, subglabrous apically, hairs more subglabrous apically, hairs more prevalent and longer, to 0.5 mm, just above sheath, 9.1–41.3 cm in subtending leaf, 32–108 cm in basal leaves; pulvinus elliptic in cross-section, olive-green, minutely tomentose in narrow band adaxially, the rest glabrous, hairs

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FIG. 1. *Calathea croatii* H. Kenn. Holotype. Type scan provided by Missouri Botanical Garden (*Croat 67776*, MO).



FIG. 2. *Calathea croatii* H. Kenn. **A.** Habit. **B.** Young inflorescence with flowers. **C.** Older, fruiting, inflorescence. Note, widely spread bracts. **D.** Detail of flower (*Black & A. Rodriguez 37*, PMA, photos by Carla Black).

TABLE 1. Comparison of leaf and inflorescence characters among three described Panamanian species and one new one, *Calathea croatii*, in the "*C. lanicaulis* Group."

Character	*Calathea allenii*	*Calathea confusa*	*Calathea guzmanioides*	*Calathea croatii*
Minor veins between major veins	1–3	7	7	7
Pubescence on major veins	glabrous	tomentose to subglabrous	tomentose (rarely glabrous)	glabrous
Infl. height (cm)	11–21	12–17.5	(16–)18–38	14–22
× width (cm)	× 3–5	× 3.5–5.1	× 7–12	× 7.5–15.4
No. of bracts	16–45	18–30	25–65	31–45
Bract apex	emarginate inflexed, cupped	emarginate inflexed, cupped	obtuse to rounded, patent to recurved	acute, recurved
Sepal length (mm)	30–32	30–36	13–23	21–23

0.2–0.25 mm, 1.5–2.8 cm; leaf blade somewhat chartaceous, ovate, apex obtuse to rounded with acumen up to 1.9–2 cm, base rounded to subtruncate shortly abruptly attenuate, 34–58 × 8–21 cm in subtending leaf, 36–95 × 8–33 cm in basal leaves (length:width ratios 2.76–4.25[–4.43]:1) lateral veins 30 to 33 per 3 cm (measured at midpoint of each side of blade), adaxial surface matte green, glabrous, midrib yellow to greenish yellow, glabrous, abaxial surface light green, minutely tomentose along major veins, midrib yellow with caramel tinge, densely appressed tomentose along sides, minutely so along center in basal ¼, appressed tomentose throughout apically, hairs colorless, 0.25–0.7 mm. **Inflorescence** terminal, 1 per shoot, imbricate when young, lax in fruit, ovoid to broadly cylindrical, 14–22 × 7.5–15.4 cm; peduncle dark red-purple, densely appressed tomentose, 1.8–2.8 cm. **Bracts** 31–45, spirally arranged, herbaceous apically, ovate to narrowly ovate, apical ones proportionally longer and narrower, apex acute, very tip occasionally blunted, apex recurved, apical 0.5 cm of margin smooth, subsequent 1–1.5 cm markedly undulate, 5–7.5 × 1.8–2.8 cm, abaxial surface of bracts dark red-purple, appressed tomentose, hairs faint straw-colored, 0.4–0.7 mm, adaxial surface dark red-purple, basalmost 1–1.5 cm pale pink to white, recurved apex dark, almost blackish, purple in younger, flowering inflorescences, sparsely pilose near apex, glabrous basally, bracts in age, in fruit, becoming deep red with apex and apical margins dying; bicarinate prophyll membranous, ovate to elliptic, apex obtuse, translucent cream-white, tinged red-purple at apex, 2.1–2.6 × 1.2–1.5 cm, 0.65–0.85 cm wide, carina to carina; secondary bracts and bracteoles unknown. **Flowers** open spontaneously. **Sepals** membranous, narrowly elliptic, cream-colored, very apex tinged pale purple, 21–23 × ca. 4 mm. **Corolla** tube cream-colored to pale yellow apically, ca. 37 mm; corolla lobes subequal, elliptic, apex obtuse, margins inrolled appearing acute, light purple abaxially, faint purple to nearly white basally adaxially, 14–16 × 4–5.5 mm. **Staminodes** 3; outer staminode broadly elliptic, apex rounded, clawed at base, apical ½ to ⅔ dark purple, basal portion yellow, ca. 13 × 9 mm; callose staminode totally callose, apex rounded or with minute acumen, yellow basally, apical ¼ dark red-purple, ca. 15 × 6 mm; cucullate staminode yellow, ca. 9 mm; stamen yellow with lateral petaloid appendage; ovary smooth, cream-colored, 2.5 × 2 mm. **Seeds** 5.5–6 × 4.5–5 × 4–4.5 mm.

Additional specimens: **PANAMÁ. Ngäbe Buglé:** beyond Hato Chami on trail to Hacha, heavily disturbed humid forest, growing on steep embankment in 50% shade, 1200 m, 8°31'12"N, 81°46'48"W, 11 Apr 2008, *C. Black & A. Rodriguez 37* (PMA); **Coclé:**behind sawmill above El Copé, in understory of primary forest, 2400 ft, 25 Aug 1983, *W.J. Kress & B. Hammel 83-1592* (DUKE 293776).

Distribution and habitat.—*Calathea croatii* is endemic to Panama. It is known from three localities in western Panama, one in Chiriquí Prov., the type locality, a second in the adjacent, Comarca Ngäbe-Buglé and the third from Coclé Prov. It occurs in montane wet or cloud forest habitat. The first two collections were at 1200 m and the third at ca. 735 m elevation.

Discussion.—*Calathea croatii* belongs to the informally treated "*C. lanicaulis* Group" as outlined in Flora of Ecuador (Kennedy 1988:47). These species are characterized by their habit of several basal leaves with a single cauline leaf, subtending the inflorescence(s) of spirally arranged bracts, borne above an elongate stem internode. Species in the "*C. lanicaulis* Group" are predominantly South American with a single species, *C. guzmaniodes* as far north as Costa Rica (Kennedy, 2003), five described species in Panama, six in Colombia and

nine in Ecuador. *Calathea croatii* is most closely related to *C. guzmanioides* sharing a similar habit, leaf venation pattern with 7 minor veins between the major veins and inflorescence morphology. *Calathea croatii* differs from *C. guzmanioides* in the glabrous vs. tomentose major veins of the adaxial leaf surface, the bracts ovate to narrowly ovate with apex acute vs. broadly ovate to broadly elliptic with broadly obtuse to rounded apex (bract length to width ratios 2.62–2.75:1 vs. 0.95–1.78:1). *Calathea croatii* differs from the related *C. allenii* Woodson and *C. confusa* H. Kenn. by the purple to red vs. green to yellow-green bracts with an acute, recurved vs. emarginate, inflexed apex.

Etymology.—The specific epithet, *croatii,* is in honor of Thomas Croat, P.A. Schulze Curator of Botany, Missouri Botanical Garden. It is a pleasure to thus recognize his contribution to our knowledge of the Panamanian flora and thank him for the hundreds of Marantaceae specimens he has collected throughout Central and South America.

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BOOK REVIEW

ZSOLT DEBRECZY AND ISTVAN RACZ, WITH KATHY MUSIAL, ED. 2011. **Conifers Around the World: Conifers of the temperate zones and adjacent regions. Volumes 1 and 2.** (ISBN: 978-963-219-063-1 [vol. 1], 978-963-219-064-8 [vol. 2], 978-963-219-061-7 [vols. 1–2], hbk). DendroPress, Ltd., Völgy u. 12, Budapest H-1039, HUNGARY. (**Orders:** www.dendropress.com, interdendr.org, info@dendropress.com). $250.00, 2 volumes, 1089 pp., 15 lbs., 474 range maps, ~1300 morphological illus., >500 taxa represented by 3700 color photos, 9 ¼" × 12 ½".

Beautiful and spectacular color pictures of conifer landscapes, habitats, morphological characters, along with detailed drawings of vegetative and reproductive plant parts, all add something special to this book. This makes these two volumes a publication that everyone interested in plants should own and display on a coffee table or bookshelf. The high quality grade of paper is Hello Silk Paper (135/M2), chlorine-free with no bleed through. This paper has the seal of approval from the Forest Stewardship Council as a certified environment-friendly product. The book spine has pages with Smyth Sewn binding and attractive head and tail bands. Everything about this book is the highest quality I have ever seen.

The three column format of text allows for color photographic images that either are full page, two columns wide, or a vertical tier of one column. In every case the color images are sharply in focus with sufficient detail to illustrate surface features as in the Bark Gallery for different taxa. Every attempt was made to take photographs in the field, which required in some cases travel to pristine habitats in remote places. The scope of this book involved more than 30 years of documentation and 340,000 photographs.

The two volumes are organized geographically by 11 regions and alphabetically by taxa. Volume 1 begins with Europe, North Africa, Anatolia, Macronesia, and Asia, including China, Taiwan, and Japan. Volume 2 covers Western and Eastern North America, Mexico, Central America, West Indies, and the Southern Hemisphere that includes Chile, Argentina, and Australia (with particular focus on Tasmania and New Zealand). There are no keys to the genera or species. Side bars of anecdotal stories enliven specific passages.

Features of Volume 1 include an 86-page introduction that includes a number of subsections. **The Age of Discoveries** covers the history of exploration and discovery, especially in the conifer-rich regions of China and Mexico where new discoveries continue. **Conservation** includes a discussion of threats faced by conifers in natural habitats. **Plant Classification and the Challenges of Conifer Identification** gives an overview and history of botanical nomenclature and classification systems. **Morphology** contains details about habits, bark, buds, foliage, cones, and seeds accompanied by illustrative photographs and drawings. **Distribution and Climate** and **Earth History and Conifers** describe conifer geographic distribution superimposed by climatic zones. Following this extensive introduction is another section titled **Conifer Families and Genera,** represented by beautiful line drawings of key morphological characters and concise descriptions that facilitate identification of genera. This section has a separate list of references for information included in the genus descriptions.

The geographic sections follow: **Europe and Adjacent Regions, Continental Asia and Hainan, Japan and Adjacent Islands,** and **Taiwan.** Here the conifers and the regions where they are native have species plates with 3–5 detailed photographs that highlight the most characteristic traits and one image showing the trees growing in natural habitats with essential descriptive and historical information.

The bulk of Volume 2 is divided into seven geographic sections. **Western North America** (pp. 549–652), with 70 range maps, 15 genera, and 79 species and varieties, includes the oldest living trees represented by *Pinus longaeva* (Bristlecone Pine), dating back more than 4000 years, and the tallest living trees represented by

(continued on p. 168)

TWO NEW ENDEMIC SPECIES OF *CALATHEA* (MARANTACEAE) FROM ECUADOR

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ABSTRACT

Calathea neillii H. Kenn. and **Calathea fredii** H. Kenn., both endemic to Ecuador, are described as new. Both species are distinguished by their inflorescences of bright red, distichous, bracts. They are most similar in aspect to *Calathea trianae* L.B. Smith & Idrobo from Dept. Nariño, Colombia. *Calathea neillii* differs from *C. trianae* in the narrowly ovate to narrowly ovate-elliptic vs. elliptic leaf blade (length:width ratios 5.87–6.93:1 vs. 3.55–4.58:1), the shorter peduncle (1.1–1.4 vs. 10–14.6 cm), and the relatively broader inflorescence (length:width ratios 2.4–2.9:1 vs. 6.0–7.33:1). *Calathea fredii* differs from *C. trianae* by the strongly corrugated vs. smooth leaf surface, narrowly elliptic vs. elliptic leaf blade (length:width ratios [4.8–]5.24–7.45:1 vs. 3.55–4.58:1), and the purple and white vs. yellow petals.

RESUMEN

Calathea neillii H. Kenn. y **Calathea fredii** H. Kenn., ambas plantas endémicas de Ecuador, se describen como nuevas especies. Las dos se distinguen por sus inflorescencias con brácteas dísticas de color rojo brillante. Son similares en aspecto a *Calathea trianae* L.B. Sm. & Idrobo de Dept. de Nariño, Colombia. *Calathea neillii* se distingue de *C. trianae* por sus hojas con la lámina foliar de angosta ovada a angosta ovado-elíptica vs. elíptica (la relación largo /ancho 5.87–6.93:1 vs. 3.55–4.58:1), el pedúnculo más corto (1.1–1.4 vs. 10–14.6 cm), la inflorescencia relativamente más ancha (la relación largo /ancho es 2.4–2.9:1 vs. 6.0–7.33:1). *Calathea fredii* se distingue de *C. trianae* por la lámina foliar fuertemente plegada vs. plana, sus hojas angostas elípticas vs. elípticas (la relación largo /ancho ([4.8–] 5.24–7.45:1 vs. 3.55–4.58:1), y los pétalos purpúreos y blancos vs. amarillos.

Since the publication of the treatment of Marantaceae for the *Flora of Ecuador* (Kennedy et al. 1988) there has been a substantial increase in field work there. Consequently a number of new species have come to the attention of various specialists, including the two being described herein. Of the total of 96 species in the 1988 flora publication, 64 were in the genus *Calathea*. Of these, 32 species were noted as endemic with 29 in the genus *Calathea*. However, five of these 29 species were undescribed when collected in Carchi Prov., sufficiently near the border with Colombia to reasonably be expected there as well, though not yet documented. Currently a total of 69 species of *Calathea* are recognized for Ecuador: the two new species being described, two additional undescribed species plus *Calathea wallisii* (Linden) Regel, known from Perú. Borchsenius et al. (2012) included less than 15% of the species of *Calathea* in their molecular phylogeny, but were confident enough to remove most species to the resurrected genus *Goeppertia* Nees. Both of these new species herein have considerable horticultural potential as they have brilliant red bracts, a character rather uncommon in *Calathea*. I am less sanguine about their sample size, but in any case, the two species described herein seem most likely to be related to either the "*C. lanicalis* Group" (Kennedy et al. 1988), which includes the red-bracted *C. timothei* H. Kenn., or C. section *Calathea*, which has distichous bracts. Both of these groups remain in *Calathea* according to Borchsenius et al. (2012).

TAXONOMIC TREATMENT

Calathea neillii H. Kenn., sp. nov. (**Figs. 1, 3**). TYPE: ECUADOR. ZAMORA-CHINCHIPE: Cantón Yantzaza, Cordillera del Cóndor region, Río Machinaza watershed, E of Los Encuentros, Refugio de Vida Silvestre "El Zarza," near San Antonia guard post, 0.25-hectare forest inventory plot, "Aurelian Plot 9," tall wet forest, canopy 25 m tall, on mixed clay/sand soil, shady forest understory, 1560 m, 03°50'37"S, 78°31'48"W, 20 Jul 2009, *D. Neill, W. Quizhpe & D. Vela 16668* (HOLOTYPE: QCNE; ISOTYPES ECUAMZ, MO, UCR).

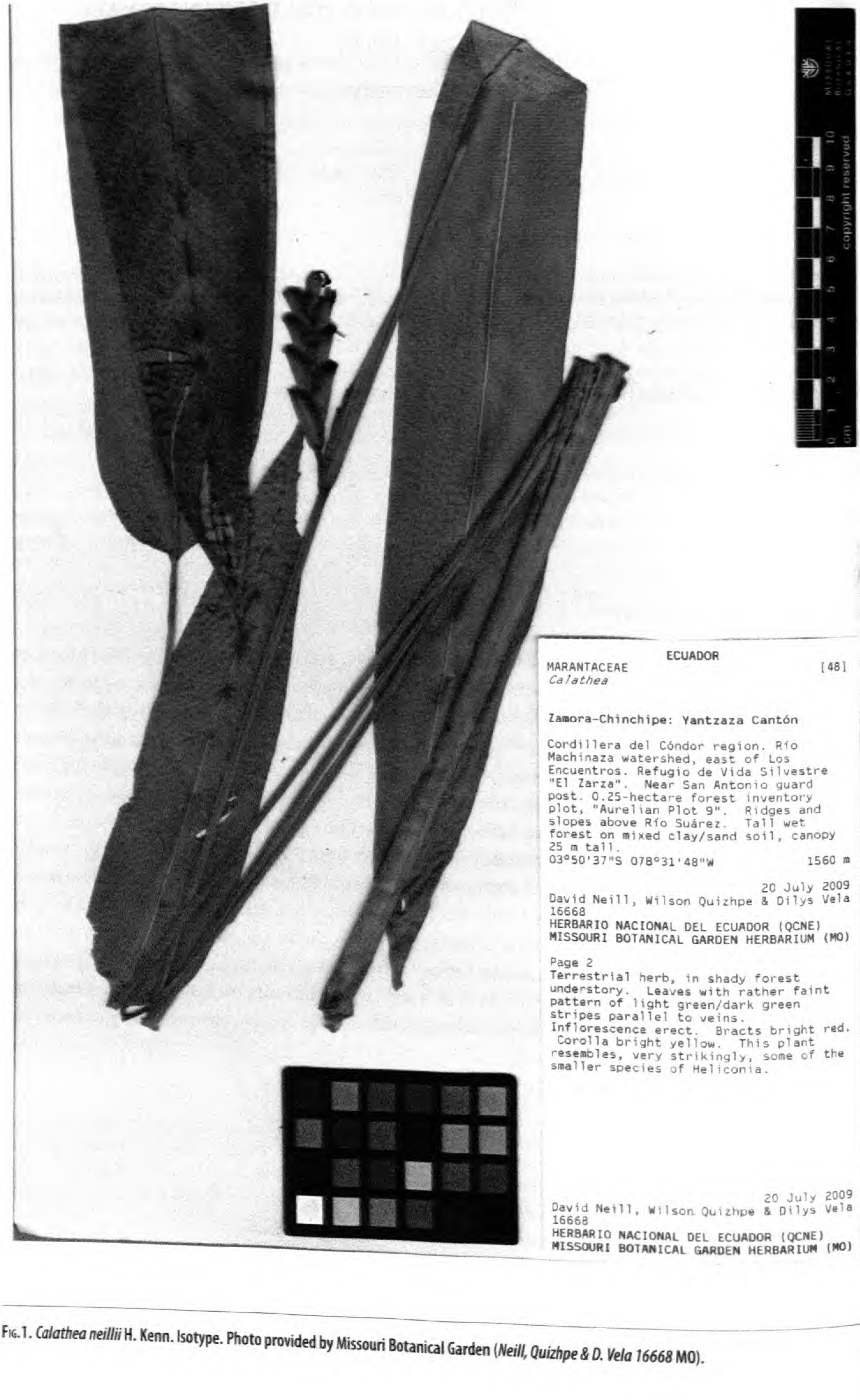


FIG. 1. *Calathea neillii* H. Kenn. Isotype. Photo provided by Missouri Botanical Garden (*Neill, Quizhpe & D. Vela 16668* MO).

Calathea neillii differs from *C. trianae* in the narrowly ovate to narrowly ovate -elliptic vs. elliptic leaf blade (length:width ratios 5.87–6.93:1 vs. 3.55–4.58:1); the shorter peduncle, 1.1–1.4 vs. 10–14.6 cm; and the relatively broader inflorescence (length:width ratios 2.4–2.9:1 vs. 6.0–7.33:1) with more closely spaced bracts (6 vs. 3 per 5 cm).

Plants rhizomatous, caulescent, herbs, ca 0.6 m high; stem dark olive-green, densely tomentose at junction to leaf sheath, bearing sparse, scattered hairs basally, hairs 0.2 mm, stem internodes between basal leaves sericeous, hairs to 4 mm. **Leaves** 4–7 basal with a single cauline leaf borne above an elongate stem internode, ca. 40 cm; leaf sheath not auriculate, sheath of subtending leaf ca. 7 cm with wings and base reddish purple, the center adaxial portion deep olive-green in upper 3/4, tomentose at base, subglabrous to glabrous apically, sheath of basal leaves 21–23 cm, tomentose apically on wings, margins densely appressed tomentose, hairs to 0.5 mm, hairs sparse on center back and wings basally; petiole green, glabrous, subglabrous just above sheath, ca. 3.5 cm in subtending leaf, (6.5–)12–18.4 cm in others; pulvinus 1–1.4 cm, olive-green, minutely tomentose, hairs to 0.5 mm, densely so adaxially, sparsely so abaxially and on sides, acuminately extended adaxially to 0.5 cm; leaf blade not ridged, the tissue between the raised major veins forming a smoothly curved shallow depression, narrowly ovate to narrowly ovate-elliptic, left side broader than right, apex acuminate attenuate, base obtuse to 90°, shortly abruptly attenuate; 24.5–31.4 × 3.6–4.6 cm (length:width ratios 5.87–6.93:1), generally 7 minor veins between major veins, vein angle from midrib 40° to 50°, lateral veins ca. 13 per 2 cm, cross-veinlets 30 to 40 per 5 mm (veins measured at midpoint of each side of blade), adaxial surface semi-shiny deep green, major veins minutely tomentose, in the basalmost 1 cm, the hairs are also present in the area between the veins, the marginal 2 mm of right side of blade minutely tomentose with the acumen densely so, hairs colorless, 0.1–0.3 mm, midrib paler, whitish green, minutely tomentose, abaxial leaf surface light green, glabrous, midrib glabrous except basal 1.5 cm tomentose where pulvinar cells extend onto midrib. **Inflorescence** terminal, 1 per shoot, ellipsoid-rectangular, ca. 5 × 1.5 cm; peduncle rose-red, densely appressed tomentose apically at junction to bract, 1.1–1.4 cm. **Bracts** 7–8, distichous, subrotund, apex retuse, margins and apex straight, not recurved, 2.1–2.3 × 1.9–2.2 cm, each subtending up to 3 or more flower pairs, abaxial surface rose-red, glabrous; bicarinate prophyll membranous, ovate, apex obtuse, translucent rose-red, glabrous except appressed pilose abaxially in basal 1/3–1/2 adjacent to carinas, hairs 0.7 mm, 1.9–2.1 × 0.65–0.7 cm, 0.5–0.55 cm wide, carina to carina; secondary bracts absent; bracteoles 2 per flower pair, membranous, medial, 1 chanelled, 1 carinate, narrowly elliptic, glabrous, 1.3–1.4 (–2) × 0.3–0.35 cm. **Flowers** opening spontaneously. **Sepals** membranous, narrowly elliptic, broadly obtuse, glabrous, 14.5–15.5 × 3–3.5 mm. **Corolla** yellow, tube glabrous, 17–18 mm; corolla lobes subequal, elliptic, 6–8 × 2.5–3 mm, obtuse, margins inrolled appearing acute, sparsely pilose in apical 1/4, hairs 0.2 mm. **Staminodes** 3, yellow; outer staminode obovate, emarginate; callose staminode petaloid apically, ca.6.5 mm; cucullate staminode 3.5–4.5 mm; stamen with lateral petaloid appendage; anther 1.5–2 mm; ovary smooth, glabrous, 2–2.5 mm. **Capsule** unknown.

Distribution and habitat.—Calathea neillii is endemic to Ecuador, known only from the type locality in the Cordillera del Cóndor region of Prov. Zamora-Chinchipe. It occurs at 1560 m elevation in the shady understory of wet forest habitat. The type was collected in flower in July.

Discussion.—Calathea neillii, shares a similar general habit of several basal leaves and an inflorescence of distichous bright red bracts borne above an elongate stem internode with both *C. fredii* and *C. trianae*. *Calathea neillii* differs from *C. trianae* in the narrowly ovate to narrowly ovate-elliptic vs. elliptic leaf blade (length:width ratios 5.87–6.93:1 vs. vs. 3.55–4.58:1), minor veins usually 7 vs. 3 between major veins, the petiole glabrous vs. pilose, the shorter peduncle (1.1–1.4 vs. 10–14.6 cm), and the relatively broader inflorescence (length:width ratios 2.4–2.91 vs. 6.0–7.33:1) with more closely spaced bracts (6 vs. 3 per 5 cm). It differs from *C. fredii* in the smooth rather than strongly corrugated leaf surface, the lower vein angle from midrib (40°–50° vs. 73°–79°), the broader vein spacing (ca. 13 vs. 19–24 per 2 cm) and the yellow vs. purple petals.

Rare species from tropical wet forests, known only from a few collections, are by necessity described using a phenetic species concept. The members of the species show overall similarity and are separated from all other species by a gap in variation (Judd et al. 2008: 145). This gap requires constant differences in several genetically controlled characters in order to prevent single gene mutations or morphs in a polymorphic character from being described as species.

Etymology.—The specific epithet, *neillii*, is in honor of David Neill, Director of Investigación, Universidead Estatal Amzonica, Puyo, Ecuador, and principal investigator on the Ecuadorian "Cordillera del Condór project." As co-founder of the Estación Biológica de Jatun Sacha he has been and is a prolific collector of Ecuadorian plants, including many undescribed species, of which this one, honoring him, is an especially attractive one.

Iconography.—Images of type scans of *Calathea trianae*, to compare with those of *C. neilii* and *C. fredii* are accessible through JSTOR at http:plants.jstor.org/search?plantName="Calathea+trianae"&syn=1. A good image is that at NY of an isotype.

Calathea fredii H. Kenn., sp. nov. (**Figs. 2, 3**). TYPE: ECUADOR. NAPO: De la carretera entre Reventador y Lumbaquí, 10 km al sur, Río Tigre, bosque pluvial premontano, colinas rocosas, en margin de bosque, 800 m, 00°05'S, 77°24'W, 6 Dec 1986, *D. Neill* 7537(HOLOTYPE: MO).

Calathea fredii differs from *C. trianae* by the strongly corrugated vs. smooth leaf surface, narrowly elliptic vs. elliptic leaf blade (length:width ratios [4.8–] 5.24–7.45:1 vs. 3.55–4.58:1), the relatively broader inflorescence (length:width ratios 1.77–2.21:1 vs. 6.0–7.33:1) and the purple vs. yellow petals.

Plants rhizomatous, caulescent herbs, 0.9–1.2 m; roots stiff, wiry; stem sericeous apically adjacent to cataphyll, glabrous below; cataphylls stiff, papyraceous, narrowly ovate, apiculate, appressed tomentose to subhispid, rough to the touch, hairs, ca. 0.5 mm on minute papillae, innermost cataphyll ca. 26 cm. **Leaves** 3–8 basal and a single cauline bladeless sheath above an elongate internode of ca. 0.6–1 m; leaf sheath not auriculate, wings and adjacent sides subglabrous, center back slightly scabrid; bladeless sheath (cataphyll) subtending inflorescence 9.5–10.5 cm long, sheath of basal leaves 23–45.5 cm; petiole green, appressed tomentose adaxially in apical 1 cm, minutely scabrid below to nearly smooth above sheath, (9–)16.5–62 cm; pulvinus round in cross-section, 1.3–3.8 cm, olive-green, tomentose adaxially, the rest glabrous, hairs straw-colored 1–1.5 mm; leaf blade plicate, markedly ridged with major veins on raised ridges, minor vein in depressions between, chartaceous, narrowly elliptic, apex acuminate-attenuate, slightly eccentric, base obtuse to 90°, 31.5–48 × 5.2–10 cm (length:width ratios [4.8–] 5.24–7.45:1), lateral veins 19 to 24 per 2 cm, cross-veinlets ca. 50 per 5 mm (veins measured at midpoint of each side of blade), vein angles from midrib 73°–79°, measured at midpoint of blade, adaxial surface deep green, glabrous except sparsely pilose at base and along margin of wider side, midrib deep green, glabrous basally, apical 10 cm pilose, abaxial leaf surface grey-green, scattered pilose, each hair on a raised basal cushion of cells, hairs straw-colored, midrib yellow-green to caramel-colored, appressed pilose. **Inflorescences** 1–3 per shoot, 1 terminal, subsequent ones borne in axil of bladeless sheath, imbricate, rectangular, complanate, 5.5–8.3 × 3.1–4.6 cm; peduncle dark purple-brown, tomentose in apical 1–1.5 cm, glabrous basally, 14–21.5 cm. **Bracts** 10–13, distichous, herbaceous, very broadly obovate to rotund, apex emarginate in lowermost, obtuse with acumen in upper ones, apical margins straight, not recurved, 2–2.5 × 1.9–2.5 cm, lowermost the largest, each bract subtending up to 6 or more flower pairs, abaxial and adaxial surface of bracts red, glabrous; bicarinate prophyll membranous, ovate-triangular, apex obtuse to 90°, apiculate, translucent red, 1.8–2.2 × 1.1–1.2 cm, 0.45–0.6 cm wide, carina to carina; secondary bract membranous, ovate, apex acute, translucent red, glabrous, 1.8–2 × 0.8–0.9 cm; bracteoles 1–2 per flower pair, 1.2–1.4 × ca. 0.15 cm, membranous, medial, carinate, or if 2, the second channeled, very narrowly elliptic to linear, glabrous. **Flowers** opening spontaneously. **Sepals** membranous, very narrowly elliptic to sublinear, apex obtuse, 15–16 × 2 mm. **Corolla** tube 15–16 mm, cream, glabrous except for a few appressed hairs in a line in apical 1/2, hairs 0.7–1 mm; corolla lobes subequal, elliptic, 6–6.5 × ca. 2 mm, acute, apical 2/3 purple, cream-colored toward base, glabrous. **Staminodes** 3; callose staminode, ca. 6 × 2.5 mm; cucullate staminode ca. 4 mm, data unavailable on outer staminode and stamen due to condition of specimen. **Ovary** smooth, pilose at apex, hairs colorless to 2 mm, ca. 2 mm. **Capsule** unknown.

Additional specimens examined: **ECUADOR. Napo:** Bermejo Oil Fields, off road from Baeza to Lago Agrio, 800–1000 m, 9 Feb 1986, A. Hirtz, C. Luer, J. Luer & A. Embree 2703 (MO 6383926); **Sucumbíos:** Sinangoe Station, Shishicho Ridge, Alto Aguarico drainage, above (S of) Río Cofanes, W of Puerto Libre, NW of Lumbaqui, access from Río Sieguyo, ridgeline trail above camp, foothills, short, 10–20 m tall, upper hill-forest on steep ridges, slopes on acid soils, 1300–1450 m, 00°12'01.3"N, 77°31'54.3"W, 14 Aug 2001, *R. Aguinda, N. Pitman & R. Foster 1323* (F 2231892).

MISSOURI
BOTANICAL GARDEN
HERBARIUM
№ 3464245



(David A. Neill 7537)

MARANTACEAE [48]
Calathea fredii H. Kenn.

det. H. Kennedy (UBC), 2013

ECUADOR

Marantaceae

Calathea fredii Sp. nov.

NAPO
De la carretera entre Reventador y Lumbaqui, 10 km al sur. Río Tigre.
Bosque Pluvial Premontano.
Colinas rocosas.

00°05'S; 77°24'W
800 m.
Hierba erecta.
En la márgen del bosque.
Flores verdes.
Brácteas rojas.
No duplicates at MO

David Neill 6/Dic/1986
7537
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)

FIG. 2. *Calathea fredii* H. Kenn. Holotype. Photo provided by Missouri Botanical Garden (*Neill 7537*, MO).

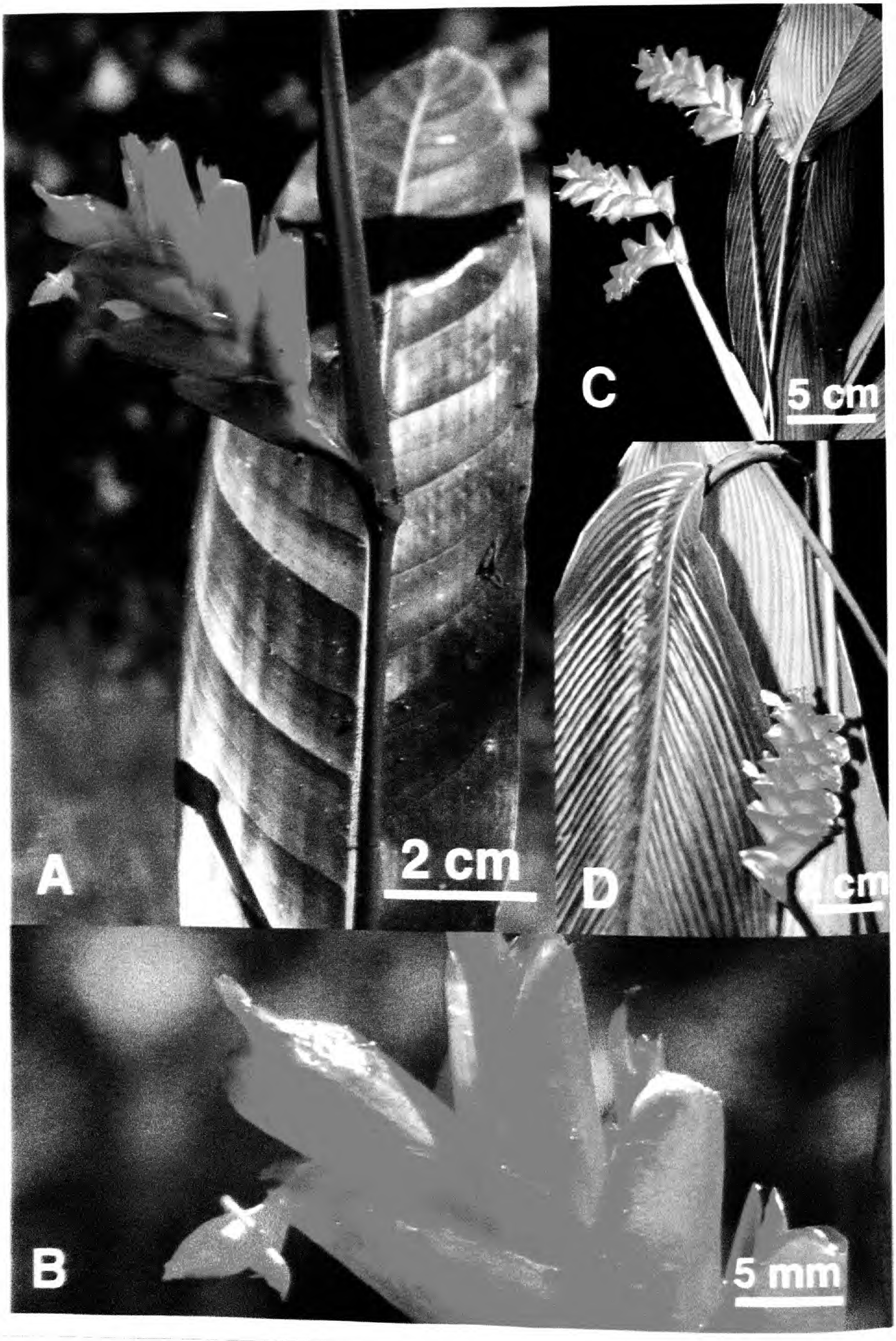


Fig. 3. *Calathea neillii* H. Kenn. **A.** Inflorescence and adaxial leaf surface. **B.** Detail of bracts and flower. *Calathea fredii* H. Kenn. **C.** Inflorescences and corrugated leaf showing abaxial surface at base. **D.** Inflorescence with flowers showing leaf adaxial surface at base. (A, B From type collection, *D. Neill, W. Quizhpe & D. Vela 16668*, photos by David Neill. C, D *R. Aguinda, N. Pitman & R. Foster 1323* (F), photos by Robin Foster.)

Distribution and habitat.—*Calathea fredii* is endemic to Ecuador. It occurs in eastern Amazonian Ecuador in Napo and Sucumbíos Provinces from 800–1450 m in premontane rain forest habitats. Flowering material was collected in December and February as well as in August.

Discussion.—*Calathea fredii* shares the similar habit and inflorescence of distichous bright red bracts with the related *C. neillii* and *C. trianae*. It would key out in Flora of Ecuador (Kennedy 1988: 47) under lead 31A because of the distichous bracts. It differs from *C. neillii* in the strongly corrugated vs. smooth leaf surface, the higher vein angle from midrib (73°–79° vs. 40°–50°) the narrower vein spacing (19–24 vs. ca.13 per 2 cm) and the purple and white vs. yellow petals. *Calathea fredii* differs from *C. trianae* by the strongly corrugated vs. smooth leaf surface, narrowly elliptic vs. elliptic leaf blade (length:width ratios [4.8–]5.24–7.45:1 vs. 3.55–4.58:1), and the purple and white vs. yellow petals. Also, it differs from *C. neillii* and *C. trianae* in lacking a bladed leaf subtending the inflorescence. Here the leaf is bladeless, reduced to essentially to the leaf sheath.

Etymology.—The specific epithet, *fredii*, is in honor of Fred R. Ganders, professor emeritus and former director of the UBC herbarium, in gratitude for his help writing the keys for the Flora of Ecuador treatment, supporting my research trips, paying for needed equiptment to carry out such work, as well as for many other trips to botanize and sample wine.

ACKNOWLEDGMENTS

The Missouri Botanical Garden provided support for my accommodations while working in the MO herbarium (organized, thanks to Olga Martha Montiel). Fred Ganders provided the travel expenses for the trips to MO and UCR. I thank David Neill for collecting both *C. neillii* and *C. fredii* and for the use of his photographs of *C. neillii*. I thank Robin Foster for the use of his color photographs of *C. fredii*, his collections and scans of the Field Museum specimens of it, and John Kress for the color slide of *C. trianae*. I thank Mary Merello for help in the MO herbarium and arranging for the type scans of *C. neillii* and *C. fredii*. Thanks to Gordon McPherson and an anonymous reviewer for their helpful corrections and suggestions and to Barney Lipscomb for providing pertinent literature as well as helpful advice. I am grateful to Andrew Sanders for providing facilities at the UCR herbarium and to Teresa Salvado for providing accommodations and transportation in Riverside. Missouri Botanical Garden provided the type scans.

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BOOK REVIEW

Zsolt Debreczy and Istvan Racz, with Kathy Musial, ed. 2011. **Conifers Around the World: Conifers of the temperate zones and adjacent regions. Volumes 1 and 2.** (ISBN: 978-963-219-063-1 [vol. 1], 978-963-219-064-8 [vol. 2], 978-963-219-061-7 [vols. 1–2], hbk). DendroPress, Ltd., Völgy u. 12, Budapest H-1039, HUNGARY. (**Orders:** www.dendropress.com, interdendr.org, info@dendropress.com). $250.00, 2 volumes, 1089 pp., 15 lbs., 474 range maps, ~1300 morphological illus., >500 taxa represented by 3700 color photos, 9 ¼" × 12 ½".

(continued from p. 160)

Sequoiadendron giganteum (Sierra Redwood). *Pinus edulis* (Pinyon Pine), as the name implies, has edible seeds important as a food item for Native Americans and wildlife. The section covering **Eastern North America** (pp. 653–701) has 32 range maps, 10 genera, and 34 species and varieties. **Mexico and Central America** (pp. 702–830) has 80 range maps, 8 genera, and 95 species and varieties. *Abies hidalgensis* (Hilalgo Fir), *Abies neodurangensis* (New Durango Fir), and *Abies zapotekensis* (Zapotek Fir) were described as new species from this area in 1995. These are distinct species but were isolated as small populations in more remote areas and were previously undiscovered. This emphasizes that even tree species that are conspicuous life forms because of their larger size still represent the lure of the unknown as undiscovered new species. Another interesting story is that of *Pinus maximartinezii* (Big Cone Pinyon Pine). Described as new in 1964, it was actually first discovered at a food market in Juchipila, southern Zacatecas, Mexico, where Jerzy Rzedowski found its edible seeds being sold as a delicacy. Additional sections of Volume 2 include the **West Indies and Bermuda, Chile and Argentina, Australia and Tasmania,** and **New Zealand.**

There is also a unique Bark Gallery chapter containing 646 color images taken in natural settings; a 6-page graphic essay of the pollen cones of each genus; and 474 distribution maps that show a visual image of the natural range of each species discussed. The Appendix in Volume 2 includes images and concise descriptions of 28 additional taxa, a glossary, references, lists of the covered conifers by scientific and common names, and a quick finder index.

This book is written in nontechnical narrative that will have broad appeal to a wide readership including the lay public, general botanists, foresters, horticulturists, and dendrologists. College, university, and public libraries will want to have this affordable book included in their biodiversity section. This book will be a valuable addition to botanical gardens, herbaria, nature centers, and national forest and national park visitor centers.—*Harold W. Keller, Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

EL GÉNERO *POLYPOGON* (POACEAE: AGROSTIDINAE) EN CHILE

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Casilla 160-C, Concepción, CHILE

RESUMEN

Se realizó una revisión taxonómica del género *Polypogon* Desf. s.l. (incl. *Chaetotropis*), en Chile. Se reconoce la presencia de 11 especies y 2 variedades de *Polypogon* para el país. Se proponen tres nuevas combinaciones [**Polypogon elongatus** Kunth var. **longearistatus** (Nicora) Finot, **P. exasperatus** (Trin.) Renvoize var. **kuntzei** (Mez) Finot y **P. magellanicus** (Lam.) Finot]. Se revalidan *P. cachinalensis* Phil. y *P. elongatus* var. *strictus* E. Desv. *Polypogon purpurascens* Phil. se considera sinónimo de *P. interruptus* Kunth, no de *P. australis* Brongn. y *P. affinis* Brong. se traslada a la sinonimia de *P. elongatus* como había sido originalmente propuesto por Desvaux (1854). Se designan los lectotipos de *Agrostis exasperata* Trin. var. *purpurascens* Kuntze, *A. pectinata* Hack. & Arechav., *A. tehuelcha* Speg., *Polypogon rioplatensis* Herter f. *elegans* Herter y *P. longiflorus* Nees ex Trin. Se extienden las distribuciones de *P. australis* hasta la Región de Arica y Parinacota y de *P. chilensis* (Kunth) Pilg. hasta la Región de Atacama. Se descarta la presencia de *P. maritimus* Willd. en Chile. Se incluyen descripciones, sinonimia, ilustraciones y especímenes examinados así como una clave para el reconocimiento de las especies.

ABSTRACT

A taxonomic revision of the genus *Polypogon* Desf. s.l. (incl. *Chaetotropis*) in Chile was made. Eleven species and two varieties of *Polypogon* are recognized. Three new combinations are proposed [**Polypogon elongatus** Kunth var. **longearistatus** (Nicora) Finot, **P. exasperatus** (Trin.) Renvoize var. **kuntzei** (Mez) Finot and **P. magellanicus** (Lam.) Finot]. *Polypogon cachinalensis* Phil. and *P. elongatus* var. *strictus* E. Desv. were revalidated. *Polypogon purpurascens* Phil. is considered a synonym of *P. interruptus* Kunth, not of *P. australis* Brongn., and *P. affinis* Brong. moves to the synonymy of *P. elongatus* as was originally proposed by Desvaux (1854). Lectotypes of *Agrostis exasperata* Trin. var. *purpurascens* Kuntze, *A. pectinata* Hack. & Arechav., *A. tehuelcha* Speg., *Polypogon rioplatensis* Herter f. *elegans* Herter and *P. longiflorus* Nees ex Trin. are designated. The distribution of *P. australis* was extended to the Region of Arica and Parinacota and *P. chilensis* to the Region of Atacama. The presence of *P. maritimus* Willd. in Chile is rejected. Descriptions, synonymy, illustrations, specimens examined, and a key to species recognition are given.

INTRODUCCIÓN

El género *Polypogon* Desf. (gr., *polys* = muchos; *pogon* = barba) (Watson & Dallwitz 1992), pertenece a la subtribu Agrostidinae, tribu Poeae y subfamilia Pooideae de la familia Poaceae (Soreng et al. 2003). Clayton & Renvoize (1986) lo sitúan en la tribu Aveneae subtribu Alopecurinae que reúne los géneros con espiguillas unifloras previamente incluidos en la tribu Agrostideae. La subtribu Agrostidinae sensu Soreng et al. (2003), con 16 géneros y cerca de 550 especies (Saarela et al. 2010), es el grupo más diverso del clado con "ADN plastidial tipo Aveneae" de la tribu Poeae, que reúne además a las subtribus Aveninae, Brizinae, Phalaridinae y Torreyochloinae (Soreng et al. 2012).

Algunos de los géneros incluidos en Agrostidinae son extremadamente diversos (v.gr. *Agrostis* L., ca. 220 spp.; *Calamagrostis* Adans., ca. 270 spp.) y su taxonomía aún no está completamente resuelta. Las relaciones filogenéticas han sido poco estudiadas y la circunscripción de los géneros aparece como el principal problema taxonómico en Agrostidinae (Saarela et al. 2010).

Polypogon, con unas 26 especies de áreas templadas y templado-cálidas de ambos hemisferios (Tzvelev 1983; Renvoize 1998; Giraldo-Cañas 2004; Lu & Phillips 2006), está estrechamente relacionado con el género *Agrostis* L. (Clayton & Renvoize 1986), del cual difiere principalmente por la desarticulación de la espiguilla. En *Polypogon* las espiguillas desarticulan con un fragmento o todo el pedicelo, de modo que las glumas caen junto con el antecio a la madurez del fruto. En *Agrostis* las espiguillas desarticulan sobre las glumas dejando

éstas en la inflorescencia cuando caen los frutos maduros (Clayton & Renvoize 1986). Además de estos caracteres, tienen algún interés taxonómico la estructura de la pálea, la micromorfología de la lemma y la morfología de la cariopsis (Rúgolo 1982; Finot et al. 2011b). El híbrido intergenérico ×*Agropogon lutosus* (Poir.) P. Fourn. [=*Agrostis stolonifera* L. × *Polypogon monspeliensis* (L.) Desf.], con caracteres intermedios, fue citado para Chile, bajo ×*Agropogon littoralis* (Sm.) C. E. Hubb., por Rúgolo & Molina (1997b), a partir de material recolectado en la Región de Los Lagos (Osorno y Chiloé).

Algunos autores reconocen a *Chaetotropis* Kunth como un género diferente de *Polypogon* (*v.gr.* Kunth 1835; Desvaux 1854; Pilger 1920; Skottsberg 1921; Björkman 1960; Nicora 1970, 1978, 1993; Marticorena & Quezada 1985; Nicora & Rúgolo 1987; Morrone et al. 2005; Rúgolo et al. 2008, Zuloaga et al. 2008, Rúgolo 2012a), del cual difiere fundamentalmente por la longitud de la pálea con respecto al largo de la lemma (en *Polypogon* la pálea es tan larga como la lemma; *Chaetotropis* tiene la pálea ½ del largo de la lemma o menos) y por la epidermis de la lemma provista de una malla de engrosamientos de las paredes periclinales de las células epidérmicas denominada "*trichodium net*" que está presente en *Chaetotropis* pero está ausente en *Polypogon* s.s. (Björkman 1960, Rúgolo 2012b, Favret et al. 2007). Otros autores incluyen a *Chaetotropis* en *Polypogon* sect. *Polypogonagrostis* Asch. et Graebn. (*v.gr.* Trinius 1840; Steudel 1854; Martius & Eichler 1893; Stuckert 1904; Hitchcock 1931, 1951; Macbride 1936; Rosengurtt et al. 1970; Navas 1973; Gould & Shaw 1983; Tzvelev 1983; Müller 1985; Clayton & Renvoize 1986; Tovar 1993; Renvoize 1998; Soreng et al. 2003; Barkworth et al. 2007; Finot et al. 2009, 2011a, b).

Soreng et al. (2003) citan 11 especies de *Polypogon* para el Nuevo Mundo, una de las cuales (*P. parvulus* Roseng., B.R. Arrill & Izag.), se encuentra solamente en Argentina y Uruguay (Rosengurt et al. 1970). Las otras 10 especies han sido citadas para Chile, incluyendo *P. maritimus* Willd., cuya presencia en Chile se descarta aquí; una especie, *P. linearis* Trin., es endémica de Chile; 6 especies son nativas no endémicas: *P. australis* Brongn., *P. chilensis* (Kunth) Pilg., *P. elongatus* Kunth, *P. exasperatus* (Trin.) Renvoize, *P. imberbis* (Phil.) Johow, *P. interruptus* Kunth y 2 son introducidas: *P. monspeliensis* (L.) Desf. y *P. viridis* (Gouan) Breistr.

Müller (1985) divide el género en 2 secciones: *Polypogon* sect. *Polypogon* y *P.* sect. *Polypogonagrostis* Asch. & Graebn. La sección *Polypogon*, comprende plantas perennes o anuales, con glumas aristadas desde el ápice o con el ápice bilobado y con la arista naciendo entre los lóbulos, lemma de hasta 1,5 mm de largo, epidermis de la lemma sin *trichodium net*, y pálea tan larga como la lemma. Esta sección, tipificada por *P. monspeliensis*, incluye las especies usualmente tratadas bajo *Polypogon* s.s. (*P. australis*, *P. interruptus*, *P. linearis* y *P. viridis*). La sección *Polypogonagrostis* comprende plantas perennes con glumas aristadas desde el ápice, lemmas de ca. 1,5 mm de largo, pálea de ⅖–⅓ del largo de la lemma y epidermis de la lemma con *trichodium net* (Müller 1985). *Polypogon* sect. *Polypogonagrostis*, tipificada por *P. elongatus* Kunth [= *Ch. elongata* (Kunth) Björkman], contiene las especies tratadas por algunos autores bajo el género *Chaetotropis*: *P. chilensis* (= *Ch. chilensis* Kunth), *P. elongatus* [= *Ch. elongata* (Kunth) Björkman], *P. exasperatus* [= *Ch. exasperata* (Trin.) Björkman] y *P. imberbis* [= *Ch. imberbis* (Phil.) Björkman] (Müller, 1985; Finot et al. 2011b).

En Chile continental, el género se encuentra a lo largo de todo el país y en Chile insular se le encuentra en el Archipiélago de Juan Fernández (Rúgolo & Molina 1997a; Baeza et al. 2007); crecen en lugares húmedos, arenosos o salinos junto a cursos de agua (Glenn 1987), distribución que a menudo se correlaciona con la dispersión hidrocora de las semillas (Li & Qiang 2009).

Historia taxonómica de las especies chilenas de *Polypogon s.l.*

Trinius (1824) describió la primera especie chilena del género, *P. crinitus* Trin., basada en plantas recolectadas por Eschholz & Chamisso en Chile, sin indicar una localidad específica. El nombre propuesto por Trinius es un homónimo posterior de *P. crinitus* (Schreb.) Nutt., utilizado en 1818 por Nuttall para transferir *Phleum crinitum* Schreb. al género *Polypogon*. Kuntze (1898) transfirió la especie de Trinius a *P. littoralis* Sm., con el rango de variedad [*P. littoralis* var. *crinitus* (Trin.) Kuntze] mientras que Hackel (1906) la trata como una variedad de *P. interruptus* [*P. interruptus* var. *crinitus* (Trin.) Hack.]. Actualmente, *P. crinitus* Trin. se considera un sinónimo de *P. australis*.

Brongniart (1829) describió dos nuevas especies para Chile: *P. affinis* Brongn. (= *P. elongatus*) y *P. australis*.

Kunth (1830) describió *Chaetotropis chilensis* basándose en material recolectado en "La Conception"; esta especie fue posteriormente transferida a *Polypogon* por Pilger en 1920.

Trinius (1836) describió *P. linearis*, basándose en material recolectado por Poeppig en 1827, en Concón. Describió también *P. monspeliensis* var. *interrupta* (Trinius 1836), recolectada por Poeppig en "Los Andes de Santa Rosa" (Los Andes). El tipo se encuentra en el herbario del Instituto Komarov (LE) pero el estatus del nombre aún no ha podido ser esclarecido.

Trinius (1841) describió *Agrostis exasperata* basado en ejemplares recolectados por d'Urville en Concepción. Esta especie fue posteriormente transferida por Renvoize (1998) al género *Polypogon* [*P. exasperatus* (Trin.) Renvoize]. Renvoize (1998) también transfirió *Agrostis hackelii* R.E. Fr. a *Polypogon* [*P. hackelii* (R.E. Fr.) Renvoize], que se considera un sinónimo de *P. exasperatus*.

Joseph Dalton Hooker (1846) describió *Polypogon chonoticus* Hook. f., del Archipiélago de los Chonos, sobre la base de material recolectado por Charles Darwin en diciembre de 1834; este nombre es un sinónimo de *P. australis* Brongn.

Steudel (1854) describió *Agrostis asperigluma* sobre la base de material recolectado por Lechler en Huiti, Región de Los Lagos, Chile. Esta especie fue posteriormente transferida a *Chaetotropis* por Nicora (1978) [*Ch. asperigluma* (Steud.) Nicora = *P. exasperatus* (Trin.) Renvoize]. Steudel (1854) también describió *P. radicans* Steud. (= *P. australis*), basado en material recolectado en Valdivia por Lechler. En el trabajo de Steudel (1854) se encuentra también la descripción hecha por Nees de *P. longiflorus* Nees ex Steud. (= *P. linearis*), basada en material recolectado en Valparaíso por Cumming.

Émile Desvaux (1854) describió *P. elongatus* var. *strictus*, sobre la base de material recolectado por C. Gay en Santiago. Otras variedades han sido descritas en la misma especie (var. *minor* Hack., var. *muticus* Hack. y var. *patagonica* Speg.), lo que demuestra la variabilidad de los caracteres en esta especie. Desvaux (1854) describió además dos variedades de *P. interruptus* (var. *breviaristatus* y var. *longearistata*). Ninguna de estas variedades ha sido reconocida en los tratamientos modernos de *Polypogon*. Desvaux (1854) reconoce *Polypogon* y *Chaetotropis* como géneros separados; bajo *Polypogon* incluye 6 especies: *P. crinitus* (=*P. australis*), *P. interruptus*, *P. chonoticus*, *P. monspeliensis*, *P. linearis* y *P. elongatus* y bajo *Chaetotropis* incluye sólo a *Ch. chilensis*.

El mayor número de especies fue descrito por R.A. Philippi. No obstante, la mayoría no ha sido reconocida por los botánicos modernos: [1859] *Chaetotropis latifolia* Phil. (=*P. chilensis*); [1860] *P. cachinalensis* Phil., *P. microstachys* Phil. (=*P. interruptus*); [1891] *P. tarapacanus* (=*P. interruptus*); [1896] *Chaetotropis araucana* (=*P. exasperatus*), *P. brachyatherus* (=*P. interruptus*), *P. breviaristatus* (=*P. interruptus*) y *P. purpurascens* (=*P. australis*). En este trabajo se revalida *P. cachinalensis* Phil.

Pilger (1920) transfirió *Ch. chilensis* Kunth a *Polypogon*. Bjorkman (1960) transfirió al género *Chaetotropis* tres especies: *Agrostis exasperata* Trin. [*Ch. exasperata* (Trin.) Bjorkman], *Agrostis hackelii* [*Ch. hackelii* (R.E. Fr.) Björkman] y *Nowodworskia imberbis* Phil. [*Ch. imberbis* (Phil.) Bjorkman]. Esta última especie había sido previamente transferida a *Polypogon* por Johow (1896).

Nicora (1978) transfirió *Agrostis asperigluma* Steud. al género *Chaetotropis* [*Ch. asperigluma* (Steud.) Nicora = *P. exasperatus*].

Marticorena & Quezada (1985) catalogan 7 especies de *Polypogon* en Chile: *P. australis*, *P. interruptus*, *P. linearis*, *P. lutosus* (Poir.) Hitchc. (= x *Agropogon lutosus*), *P. maritimus*, *P. monspeliensis* y *P. semiverticillata* (Forsk.) Hyl. (= *P. viridis*). Reconocen el género *Chaetotropis* con 4 especies: *Ch. asperigluma* (= *P. exasperatus*), *Ch. chilensis* (=*P. chilensis*), *Ch. elongata* (=*P. elongatus*) y *Ch. imberbis* (= *P. imberbis*).

Soreng *et al.* (2003) no reconocen el género *Chaetotropis* e incluyen en *Polypogon* s.l. para Chile: *P. australis*, *P. chilensis*, *P. exasperatus*, *P. imberbis*, *P. interruptus*, *P. linearis*, *P. maritimus*, *P. monspeliensis* y *P. viridis*. No incluyen a *P. elongatus* entre las especies con distribución en Chile.

Zuloaga *et al.* (2008) no reconocen el género *Chaetotropis* e incluyen para Chile las siguientes especies bajo *Polypogon*: *P. australis*, *P. chilensis*, *P. elongatus*, *P. exasperatus*, *P. imberbis*, *P. interruptus*, *P. linearis*, *P. maritimus*, *P. monspeliensis* y *P. viridis*.

Rúgolo (2012a,b) reconoce *Chaetotropis* con las siguientes especies para Chile: *Ch. asperigluma*, *Ch.*

chilensis, *Ch. elongata* var. *elongata* y *Ch. imberbis* var. *imberbis*. Bajo *Polypogon reconoce P. australis*, *P. brachyatherus*, *P. interruptus*, *P. maritimus*, *P. monspeliensis* y *P. viridis*.

En este trabajo reconocemos 11 especies y dos variedades de *Polypogon* para Chile. Las especies se describen e ilustran y se entregan mapas de su distribución, una clave para el reconocimiento de las especies y material estudiado de cada una de ellas.

MATERIALES Y MÉTODOS

Se estudiaron las colecciones de *Polypogon* de los herbarios BA, CONC, SGO y SI (Holmgren *et al.* 1990), el material tipo depositado en SGO y las imágenes de los tipos disponibles en JSTOR Plant Science (http://plants.jstor.org/) de los herbarios B, BAA, BAB, C, CGE, F, G, HAL, K, LP, MO, P, SGO, TDC y W. Al mismo tiempo, se consultaron las descripciones originales de las especies. Las observaciones se realizaron con un microscopio estereoscópico Zeiss SV 8 equipado con ocular micrométrico. Para diferenciar las especies se confeccionó una clave dicotómica. Las especies fueron descritas, ilustradas y se entrega la sinonimia de cada una de ellas, la iconografía, distribución geográfica y el material examinado.

RESULTADOS

Morfología

1. Ciclo de vida.—Las plantas pueden ser anuales o perennes. Todas las especies asignadas a la sección *Polypogonagrostis* son perennes con la excepción de *P. chilensis*. De la sección *Polypogon* son anuales *P. linearis* y *P. monspeliensis*.

2. Hojas.—En general, las vainas son más cortas que los entrenudos, glabras, a veces escabrosas. Las lígulas son membranáceas, de (0,5–)1–6 mm de largo, truncadas. Las láminas son planas, glabras o escabrosas.

3. Inflorescencia.—La inflorescencia es una panícula subespiciforme o laxa (abierta o contraída), raramente espiciforme (*P. cachinalensis*), muchas veces con tonalidades purpúreas. Las inflorescencias de mayor tamaño se observaron en *P. australis* (hasta 25 cm de largo, ca. 4 cm de ancho) y las más pequeñas en *P. cachinalensis* (1,2–2,3 cm de largo, 0,4–0,5 cm de ancho). La compactación de la inflorescencia ha sido considerado un carácter con valor taxonómico en *Polypogon* (Keshavarzi et al. 2007). Panículas laxas, abiertas (16–17 cm de largo, 4–5 cm de ancho), se encuentran en *P. exasperatus* y *P. magellanicus*. El raquis puede ser glabro o escabroso.

4. Desarticulación de las espiguillas.—Las espiguillas son unifloras, pediceladas y se desprenden con un fragmento de pedicelo de largo variable según la especie. En algunas especies el artejo que acompaña a la espiguilla es muy breve (v.gr. *P. monspeliensis*, 0,1–0,2 mm), en otras corresponde a casi todo el pedicelo (v.gr. *P. magellanicus*, 1–4 mm). En la sección *Polypogon*, el artejo alcanza 0,43 mm en promedio mientras en la sección *Polypogonagrostis* promedia 1,5 mm.

5. Glumas.—Las glumas son aproximadamente iguales en forma y tamaño, ambas mayores que el antecio, aristadas y usualmente escabrosas en el dorso. Las especies de la sección *Polypogonagrostis* tienen glumas más largas (1,6–5,0 mm, prom. 2,55 mm) que la sección *Polypogon* (1,3–3,1 mm, prom. 1,90 mm). La gluma inferior suele ser levemente más larga que la superior en la sección *Polypogonagrostis*. La especie con glumas más cortas es *P. cachinalensis* (1,3–2,0 mm); las glumas más largas se encuentran en *P. magellanicus* (3,2–5,0 mm).

6. Arista de las glumas.—Las glumas pueden ser aristadas o múticas, a veces mucronadas. *Polypogon chilensis*, *P. exasperatus* var. *exasperatus*, *P. magellanicus* y *P. viridis* carecen de aristas bien desarrolladas. Las aristas más largas (ca. 15 mm) se observaron en *P. australis* y las más cortas (0,3–0,5 mm) en *P. cachinalensis*. La arista nace en el ápice de la gluma o inmediatamente por debajo del mismo. En *P. elongatus*, el cuerpo de la gluma se extiende insensiblemente para formar una arista apical. Las características de las glumas, especialmente de la arista (longitud y posición) han sido utilizados como caracteres de valor taxonómico (Keshavarzi et al. 2007).

7. Lemma.—La lemma es notablemente menor que las glumas, hialina, glabra, 5-nervia. El ápice es truncado y los nervios suelen extenderse más allá del ápice como breves arístulas, todas del mismo largo o bien las exteriores más largas. La lemma es mútica o posee una arista inserta cerca del ápice o en la zona media del dorso; puede ser recta o geniculada, exserta o no, a veces fácilmente caediza.

8. Malla de engrosamientos en la epidermis de la lemma (*trichodium net*).—El denominado "*trichodium net*" corresponde a engrosamientos en las paredes periclinales de las células epidérmicas de la lemma. La presencia de esta malla está ausente en todas las especies pertenecientes a la sección *Polypogon* y está presente en la sección *Polypogonagrostis*. En *P. magellanicus* y *P. exasperatus* var. *kuntzei* los engrosamientos periclinales están ausentes (Finot et al. 2011b).

9. Pálea.—La pálea es hialina, 2-nervia y puede ser tan larga como la lemma (sección *Polypogon*) o más corta que ésta (sección *Polypogonagrostis*), alcanzando aproximadamente ½ del largo de la lemma. La longitud de la pálea en relación con la longitud de la lemma ha sido considerado un buen carácter para reconocer a *Chaetotropis* como un género independiente de *Polypogon* (v. gr. Nicora & Rúgolo 1987).

10. Cariopsis.—La cariopsis puede ser ovoidal o elipsoidal, con surco ventral más o menos marcado; escudete embrional aproximadamente de ¼ de la longitud de la cariopsis; hilo punctiforme. Nicora & Rúgolo (1987) otorgan valor taxonómico a la morfología de la cariopsis para separar *Chaetotropis* de *Polypogon*.

TRATAMIENTO TAXONÓMICO

Polypogon Desf., Fl. Atlant. 1:66. 1798. Especie tipo: *P. monspeliensis* (L.) Desf.

Anuales o perennes, cespitosas o rizomatosas. Cañas de 10 a 120 cm de alto. Lígulas membranáceas, glabras o escabrosas; Láminas planas. Espiguillas unifloras, pediceladas, desprendiéndose con el pedicelo o un fragmento del mismo de largo variable según la especie. Glumas más largas que el antecio, subiguales, 1-nervias, escabrosas, el ápice agudo o bilobado, terminado en una arista dorsal o subapical de largo variable, a veces ausente. Lemma hialina, glabra, 5-nervia, con el ápice truncado, denticulado, mútico o con arista inserta cerca del ápice o en la zona media del dorso de la lemma, a veces los nervios laterales prolongados más allá del ápice en arístulas breves. Pálea hialina, 2-nervia tan larga como la lemma o menor que ésta. Flor perfecta; lodículas glabras, agudas o redondeadas en el ápice; estambres 3; ovario con estilos cortos y estigmas plumosos. Cariopsis ovoide o elipsoide; surco ventral más o menos marcado; escudete embrional aproximadamente de ¼ de la longitud de la cariopsis; hilo punctiforme.

Distribución geográfica.—Género cosmopolita, principalmente de regiones templadas o templado-cálidas aunque en las regiones tropicales puede encontrarse también en las montañas (Kabeer & Nair, 2007). En la Argentina, Zuloaga et al. (2008) reconocen 7 especies: *P. australis*, *P. brachyatherus* Phil., *P. interruptus*, *P. linearis*, *P. maritimus*, *P. monspeliensis* y *P. viridis*. En Bolivia, Renvoize (1998) cita 5 especies: *P. elongatus*, *P. exasperatus*, *P. hackelii* (= *P. exasperatus*), *P. interruptus*, *P. monspeliensis* y *P. viridis*. En Perú, Tovar (1993) señala 4 especies: *P. elongatus*, *P. interruptus*, *P. monspeliensis* y *P. viridis* (bajo *P. semiverticillatus*), a las que debe agregarse *P. exasperatus* cuyo sinónimo, *Vilfa acutiglumia* Steud. ex Lechler, fue descrito para Perú. Habitan en suelos arenosos y sobre todo húmedos. En Chile se distribuye desde la Región de Arica y Parinacota, hasta la Región de Magallanes y Antártica Chilena, incluyendo algunas especies en el Archipiélago de Juan Fernández.

CLAVE DE LAS ESPECIES DE *POLYPOGON* EN CHILE

1. Plantas anuales; panícula espiciforme.
   2. Glumas múticas o mucronadas; quilla de las glumas pectinado-espinulosa, con espínulas de 0,2–0,5 mm de largo; espiguillas se desprenden con un artejo de 0,5–2 mm de largo; lemma mútica o con arista de hasta 1,2 mm de largo; pálea menos de ½ del largo de la lemma _____ **3. P. chilensis**
   2. Glumas aristadas; quilla de las glumas escabrosa; espiguillas se desprenden con un artejo de 0,1–0,6 mm de largo; lemma con arista de 0,8–3 mm de largo; pálea subigual a la lemma.
      3. Espiguillas de 3–3,8 mm de largo; glumas lineares, algo desiguales, la inferior algo más larga que la superior, aristadas desde el ápice; arista de 5–7 mm de largo _____ **8. P. linearis**
      3. Espiguillas de 1,4–2,2 mm de largo; glumas linear-lanceoladas, subiguales en largo, bilobadas en el ápice, aristadas desde la incisión de los lóbulos del ápice; arista de 2–5 mm de largo _____ **10. P. monspeliensis**
1. Plantas perennes; panícula laxa, subespiciforme o espiciforme.
   4. Glumas múticas o mucronadas.
      5. Pálea tan larga como la lemma; glumas de 1,5–2 mm de largo, con el ápice generalmente obtuso, a veces con mucrón no mayor de 0,3 mm de largo; panícula contraída, densa, lobulada; lemma mútica con el ápice 4-dentado _____ **11. P. viridis**

5. Pálea cerca de ½ del largo de la lemma o reducida; glumas mayores de 2 mm de largo, múticas o mucronadas; panícula laxa o contraída; lemma aristada.
   6. Espiguillas de 3–5,5 mm de largo; lemma con arista de 2–6 mm de largo, geniculada y retorcida _____ **9. P. magellanicus**
   6. Espiguillas de (1,5–)2–3 mm de largo; lemma con arista de (0,7–)1,5–2,3 mm de largo, recta o geniculada _____ **5. P. exasperatus**
4. Glumas aristadas.
   7. Panícula espiciforme o subespiciforme, lobulada; glumas desiguales, la inferior mayor que la superior, arista de 0,8–1,7 mm de largo; lemma mútica _____ **6. P. imberbis**
   7. Panícula laxa o contraída; glumas subiguales; lemma generalmente aristada (excepto *P. cachinalensis*)
      8. Glumas lanceolado-subuladas, angostándose imperceptiblemente hacia el ápice para formar la arista; pálea menos de ½ del largo de la lemma _____ **4. P. elongatus**
      8. Glumas lanceoladas, terminando abruptamente en ápice agudo o lobado, con arista subapical; pálea tan larga como la lemma.
         9. Plantas pequeñas, de 5–20 cm de alto; panículas espiciformes de hasta 2,5 cm de largo; glumas bilobadas en el ápice, con arista subapical de 0,3–0,5 mm de largo; lemma mútica _____ **2. P. cachinalensis**
         9. Plantas mayores (16–125 cm de alto); panículas contraídas mayores de 3 cm; glumas agudas o brevemente bilobadas; lemma aristada.
            10. Arista de las glumas hasta de 14 mm de largo, onduladas, 4–6 veces más largas que las glumas _____ **1. P. australis**
            10. Arista de las glumas hasta de 4 mm de largo, usualmente tan largas como las glumas _____ **7. P. interruptus**

1. Polypogon australis Brongn., Voy. Monde 2:21. 1829. TIPO: Près de la ville de la Conception, au Chili, Jan 1825, D. Lesson, D. Urville (HOLOTIPO: P no visto; ISOTIPOS: US-fragm. ex P no visto).

Polypogon adscensionis Trin., Mém. Acad. Imp. Sci. Saint-Pétersbourg, Sér. 6, Sci. Math., Seconde Pt. Sci. Nat. 6.4(3–4):257. 1841. TIPO: Ins. Adscensionis, Ecklon s.n. (HOLOTIPO: LE-TRIN-1560.01 no visto; ISOTIPO: US-fragm. ex LE-TRIN no visto).

Polypogon chonoticus Hook. f., Fl. Antarct. 2:374. 1846. TIPO: CHILE: Archipiélago de los Chonos, Cape Tres Montes, Dec 1834, C. Darwin 510 (LECTOTIPO: BM no visto; ISOLECTOTIPOS: CGE imagen internet!, K imagen internet!, US-fragm. ex K no visto); Lectotipo designado por D.M. Porter, Bot. J. Linn. Soc. 93:39 (1986).

Polypogon crinitus Trin., Gram. Unifl. Sesquifl. 171. 1824, non *P. crinitus* (Schreb.) Nutt., Gen. N. Amer. Pl. 1:50. 1818. *Polypogon littoralis* var. *crinitus* Kuntze, Revis. Gen. Pl. 3:367. 1898. *Polypogon interruptus* var. *crinitus* (Kuntze) Hack., Anales Mus. Nac. Buenos Aires 13:473. 1906. TIPO: "CHILI:" *Eschholz & Chamisso.* (HOLOTIPO: LE-TRIN-1564.04, no visto; ISOTIPO: US-fragm. ex LE-TRIN, no visto).

Polypogon elongatus var. *patagonica* Speg., Revista Fac. Agron. Veterin. (Buenos Aires) 3(30–31):582. 1897. TIPO: ARGENTINA: Patagonia, Río Santa Cruz, 1894, in pratis uliginosis secus, *Sr. C. Ameghino* (probable HOLOTIPO: LP imagen internet!).

Polypogon radicans Steud., Syn. Pl. Glumac.1:184. 1854. TIPO: CHILE: Valdivia, prope col. Arique, Jan 1852, *Lechler 444* (HOLOTIPO: P imagen internet!; ISOTIPOS: G imagen internet!, LE no visto, P imagen internet!, US-82087-fragm. ex P & ex LE no visto, W-Rchb 1889-0023523 imagen internet!).

Perennes; cañas de 35–125 cm; entrenudos de 7–17 cm de largo; nudos 2–3. Vainas de 6–14 cm de largo, más cortas o tan largas como los entrenudos, glabras o levemente escabrosas hacia el ápice; lígulas de (0,5–)2–4 mm de largo, levemente escabrosas en el dorso, el ápice truncado y denticulado; láminas planas de 5–16 cm de largo por 1–8 mm de ancho, escabrosas en ambas caras o, menos frecuentemente, glabras. Panículas contraídas a subespiciformes, de 6–18 cm de largo por 2–4 cm de ancho, verde-amarillentas a purpúreas; raquis glabro. Espiguillas se desprenden con un fragmento de pedicelo de 0,5–1 mm de largo; pedicelos de 0,8–2 mm de largo, escabrosos; glumas subiguales de 1,5–2,5 mm de largo por 0,4–0,6 mm de ancho, escabrosas en el dorso, ápice agudo o levemente lobado, provisto de una arista subterminal de 5–10(–14) mm de largo, usualmente ondulada; lemmas hialinas, de 1–1,8 mm de largo, con el ápice truncado, 5-nervias, los nervios laterales e intermedios prolongados en cuatro arístulas de las cuales las dos externas son más largas que las internas; arista de 3–8 mm de largo, inserta en el tercio superior del dorso de la lemma, a 0,2–0,35 mm del ápice, ondulada menos frecuentemente recta, exserta; callo glabro; pálea de 0,9–1,4 mm de largo, tan larga como la lemma; lodículas de 0,5 mm de largo, hialinas, agudas; anteras de 0,4–0,8 mm de largo. Cariopsis elipsoidal, de 0,9–1,2 mm de largo por 0,25–0,4 mm de ancho, con marcada depresión ventral; endosperma blando.

Iconografía.—Hitchcock (1951: 365, fig. 513); Nicora (1978: 396, fig. 262a-e); Rúgolo (2012b: 341).

Fenología.—Florece y fructifica entre septiembre y marzo.

Distribución geográfica y hábitat.—Habita en Argentina, Chile, México y USA. Crece en zonas húmedas, a orillas de canales o esteros, suelos arenosos y sitios pantanosos. En Chile se extiende desde la región de Arica y Parinacota (Chapiquiña, 18°12'S) hasta la Región de Aysén (Lago Bertrand, 47°02'S) y desde el nivel de mar hasta los 4000 m de altitud.

Caracteres distintivos.—Se caracteriza por sus panículas amplias con espiguillas provistas de glumas con aristas muy largas (4–6 veces más largas que las glumas), onduladas. Especie muy cercana a *P. interruptus*, se distingue de ésta por las aristas de las glumas más largas (hasta 14 mm en *P. australis*, hasta 4 mm en *P. interruptus*), por la lemma con el ápice 4-aristulado, las dos arístulas marginales más largas que las arístulas internas (las cuatro arístulas de la lemma iguales en *P. interruptus*).

Material adicional estudiado.—**ARGENTINA. Neuquén:** Quila-Quina, Lago Lácar, *Sánchez 228* (BA). **Salta:**Chicoana por Cachi, Valle Encantado, *Novara et al. 1039* (SI). **San Juan:** Jáchal, Quebrada Gualcamayo, entre Chépical y El Salto, *Roig 2187* (BA). **CHILE:** *Joseph 3316* (CONC); Salto, *Philippi s.n.* (SGO). **Región de Arica y Parinacota:** Arica, 20 m, *Jaffuel 1109* (CONC); Arica, Chapiquiña, 4000 m, *Zoellner 3926* (CONC); Arica, Valle de Azapa, 150 m, *Schlegel 4866* (CONC); Parinacota, cerca de Putre, 3300 m, *Arroyo 597* (CONC). **Región de Tarapacá:** Iquique, Corsa, 1300, *Chong s.n.* (CONC); Iquique, Mamiña, 2700 m, *Richter s.n.* (CONC); Iquique, Quebrada Vítor, Chaca, 500 m, *Ricardi 3426* (CONC); Iquique, Tarapacá, 1350 m, *Fernández s.n.* (CONC). **Región de Antofagasta:** Aguada Escondida, 2750 m, *Arancio & Squeo 10532* (CONC); Antofagasta, Aguada Ojos del Chaco, 3300 m, *Arancio & Squeo 10316* (CONC); Antofagasta, 150 m, *Navas 2837* (CONC); Antofagasta, Península Moreno, Cerros W de J. López, 840 m, *Baumann 47* (CONC); El Loa, Calama, Chiuchiu, 2540 m, *Pfister s.n.* (CONC); Chiuchiu, Río Loa, 2600 m, *Villagrán 2206* (CONC); Lasana, Quebrada del Loa, 2300 m, *Pisano & Venturelli 1775* (CONC); Quebrada de Socaire, 3840 m, *Rodríguez & Ruiz 3711* (CONC); Río Loa, camino de Calama a Caspana, 2480 m, *Peterson et al. 15551* (CONC); El Loa, Río San Pedro, San Pedro de Atacama, 2450 m, *Ivanovic s.n.* (CONC); Quebrada Aguas Blancas, Toconao, San Pedro de Atacama, 3200 m, *Ackermann 107*(SGO); Tilopozo, Salar de Atacama, 2300 m, *Teillier 3358* (SGO); Toconce, Terraza San Agustín, 3300 m, *Villagrán et al. 2184* (SGO). **Región de Atacama:** Chañaral, Potrerillos, 3000 m, *Arriagada s.n.* (CONC); Huasco, Vallenar, San Juan Canto del Agua, 230 m, *sin colector* (CONC); Vallenar, 1984, *Yuraszeck et al. s.n.* (CONC-CH). **Región de Coquimbo:** Choapa, Illapel, Caleta Oscuro, 50 m, *Marticorena et al. 303* (CONC); Choapa, Pangal Los Vilos, 25 m, *Jiles 2697* (CONC); Elqui, entre Juntas y Embalse La Laguna, 2850 m, *Ricardi et al. 1745* (CONC); Fray Jorge, *Muñoz 4036* (SGO); Illapel, *Landbeck s.n.* (SGO); Limarí, Cordillera de Ovalle, río Molles, 2600 m, Jiles 2867 (CONC). **Región de Valparaíso:** Aconcagua, 10 km W de Río Blanco, Cañón del río Aconcagua, 1250 m, *Hutchison 127* (SGO); Archipiélago de Juan Fernández, Isla Robinson Crusoe, Quebrada Puerto Francés, 100 m, *López 11603* (CONC); Juan Fernández, *Reed s.n.* (SGO); Juan Fernández, *Germain s.n.* (SGO); Isla Robinson Crusoe, La Vaquería, 30 m, *Stuessy & Crawford 6439* (CONC); Isla Robinson Crusoe, *Stuessy et al. 5308* (CONC); Isla Robinson Crusoe, Bahía del Padre, 10 m, *Stuessy et al. 11035* (CONC); Isla Robinson Crusoe, Cerro Agudo, 640 m, *Stuessy & Soto 11938* (CONC); Isla Robinson Crusoe, Corrales de Molina, 340 m, *Wiens et al. 11209* (CONC); Isla Robinson Crusoe, La Vaquería, 3 m, *Stuessy et al. 5505* (CONC); Isla Robinson Crusoe, La Vaquería, 80 m, *López 11407* (CONC); Isla Robinson Crusoe, Quebrada Pesca de Los Viejos, 150 m, *Ugarte & Parra 9175* (CONC); Isla Robinson Crusoe, San Juan Bautista, *Rondanelli & Humaña 11507* (SGO); Isla Robinson Crusoe, San Juan Bautista, *López & Peñailillo 11550* (SGO); Masafuera, Quebrada Tongo, *Stuessy & Ruiz 8469* (CONC); Isla Alejandro Selkirk, entre Quebrada de Las Casas y Quebrada Vacas, *Meyer 9362* (SGO); Isla Alejandro Selkirk, N de Quebrada Casas, Cementerio, 20 m, *Stuessy & Lammers 8324-A* (CONC); Isla Alejandro Selkirk, Quebrada Tongo, 30 m, *Stuessy & Ruiz 8455-A* (CONC); Los Andes, Río Aconcagua, 820 m, *Arriagada 102* (CONC); Petorca, Caleta Pichicuy, 10 m, *Soreng & Soreng 7084* (CONC); Quillota: Estero de Limache, 70 m, *Behn s.n.* (CONC); Quillota, Limache, Lliu Lliu, 255 m, *Garaventa 2532, 2842* (CONC); San Antonio, Leyda, 150 m, *Gunckel 18541* (CONC); San Felipe, Jahuel, Santa Filomena, 950 m, *Barrientos 441* (CONC); Valparaíso, Borchers s.n. (SGO); Valparaíso, Cerros de Quebrada Verde, 150 m, *Garaventa 1757* (CONC); Valparaíso, Quintero, 20 m, *Gunckel 23542, 49717* (CONC); Quintero, 20 m, *Levi 1733* (CONC); Quintero, Horcón, 10 m, *Gunckel 23490* (CONC); Quintero, Loma de La Cruz, 20 m, *Gunckel 28046* (CONC); Quintero, Los Arrayanes, 25 m, *Gunckel 23542* (CONC); Quintero, Los Arrayanes, 20 m, *Gunckel s.n.* (CONC); Quintero, Los Juanes, 20 m, *Gunckel 25964* (CONC); Quintero, Ritoque, 10 m, *Gunckel 41021* (CONC); Reñaca, 10 m, *Garaventa 3278, 3280* (CONC). **Región Metropolitana:** Cordillera de Los Andes, Frente a Santiago, 2170 m, *Teillier et al. 2541* (SGO); Cordillera de Santiago, Maipo, Ingenio Tal, 1800 m, *Grandjot & Grandjot 4753* (SGO); Cordillera, Cajón Morales, Vegas del Ruhillas, 2100 m, *Teillier & Márquez 5183* (CONC); Cajón Morales, Vegas Panimávida, 2200 m, *Teillier & Márquez 5184* (CONC); P.N. El Morado, 2170 m, *Teillier et al. 2541* (CONC); Río Clarillo, 700 m, *Araya 58, 83, 110* (CONC); Hacienda Rinconada Lo Cerda, Maipú, Quebrada de La Plata, 560 m, *Schlegel 3205* (SGO); Potrero Grande de Las Condes, 2450 m, *Grandjot s.n.* (SGO); San José de Maipo, Cajón del Río Morales, 2350 m, *Saavedra & Pauchard 3a* (SGO); Santiago, *F. Philippi s.n.* (SGO); Cajón de Maipú, Quebrada San Alfonso, 2000 m, *Levi 1041* (CONC); Cerro Manquehue, 800 m, *Díaz et al. s.n.* (CONC); Cuesta Barriga, 500 m, *Levi 2971* (CONC); El Alfalfal, Río Colorado, 1500 m, *Araya s.n.* (CONC); El Almendral, 7 Km N de Santiago, 670 m, *Araya 59* (CONC); El Canelo, 900 m, *Gunckel 45970* (CONC); El Canelo 700 m, *Gunckel 41737b* (CONC); Laguna de Aculeo, 356 m, *Gunckel 43006* (CONC); Las Condes, 900 m, *Gunckel 20886* (CONC); Las Vertientes, 800 m, *Saavedra s.n.* (CONC); Maipú, 470 m, *Gunckel 36831* (CONC); Manquehue, 750 m, *Gunckel s.n.* (CONC); Quebrada de Macul, 850 m, *Levi 1040* (CONC); Quebrada de Ramón, 1600 m, Tomé 237 (CONC); Quebrada El Yeso, 2250 m, *Araya s.n.* (CONC); Quebrada La Plata, 740 m, *Schlegel 3205* (CONC); S.N. Yerba Loca, 1700 m, *Arroyo & Humaña 855* (CONC); San Gabriel, 1500 m, *Rojas s.n.* (CONC); Vitacura, 600 m, *Quezada 265* (CONC). **Región del Libertador Bernardo O'Higgins:** Cachapoal, R.N. Río Los Cipreses, Ranchillo, 953 m, *Arroyo et al. 99270* (CONC); R.N. Los Cipreses, 1100 m, *Aedo 7074* (CONC); Cachapoal, Termas de Cauquenes, 700 m, *Pfister s.n.* (CONC); Termas de Cauquenes, 700 m, *Acevedo s.n.* (CONC); Cardenal Caro, Cerro Lunes, 345 m, *Barrientos 2048* (CONC); Colchagua, *Landbeck s.n.* (SGO); Colchagua, La Rufina, 770 m, *Barrientos 2021* (CONC); Puente Negro, Río Claro, 540 m, *Ricardi s.n.* (CONC); Quebrada Camino Vegas del Flaco, Huertecillas, 1100 m, *Ricardi s.n.* (CONC); San Fernando, Termas del Flaco, 1700 m, *Monte 965* (CONC). **Región del Maule:** Cauquenes, 177 m, *Silva & Jirkal 250* (SGO); R.N. Los Ruiles 300 m, *Finot & López 1509* (CONC); Curicó, Puntilla Norte Llico, Villagrán & Tapia III-90 (SGO); Camino Laguna de Teno con Junta P. Vergara, 2400 m, *Marticorena & Matthei 954* (CONC); Cerro Condell, 290 m, *Barros 1627* (CONC); Curicó, 200 m, *Barros 1619* (CONC); Curicó, 200 m, *Joseph 4253* (CONC); Iloca, 10 m,

Gunckel 46897 (CONC); Linares, Camino Estero Las Animas-Estero Riecillo, *Ruiz & López 1207, 1218, 1280* (CONC); Linares, Esc. Agrícola Don Bosco, 160 m, *Barrientos s.n.* (CONC); Fundo El Castillo, Río Blanco, 823 m, Ruiz & López 982 (CONC); Fundo El Castillo, Río Blanco, 823 m, *Ruiz & López 904* (CONC); R.N. Bellotos del Melado, 930 m, *Arroyo et al. 996048, 996067* (CONC); Llico, *Philippi s.n.* (SGO); Talca, Central Los Cipreses, 900 m, *Finot & López 2125* (CONC); Constitución, 30 m, *Barnier 474* (CONC); Predio Venecia, 1 Km S de Talca, 100 m, *Rodríguez & Baeza 2345* (CONC); R.N. Alto de Vilches, Camino a laguna El Alto, 1800 m, *Finot & López 1738* (CONC); Talca, 90 m, *Barros 1556* (CONC); Talca-Pencahue, 97 m, *Jirkal 38* (SGO). **Región del Bío-Bío:** Arauco: Cañete, 70 m, *Barros 1814* (CONC); Contulmo, Lago Lanalhue, 30 m, *Ricardi s.n.* (CONC); Contulmo, Río Peral, 50 m, *Behn s.n.* (CONC); Entrada Lago Lanalhue hacia Antiquina, 120 m, *Baeza & Kottirsch 1422* (CONC); Estero Ranquilco, 40 m, *Parra & Torres 973* (CONC); Lebu-Los Alamos, a 8 km de Cruce Quinahue, 70 m, *Parra & Torres 556* (CONC); Playa Lloncao, Playa Los Morros, 5 m, *Parra & Torres 362* (CONC); Playa Punta Morguilla, 5 m, *Parra & Torres 447* (CONC); Río Raqui, 5 m, *Ricardi s.n.* (CONC); Trongol Alto, Sector Alto Tres Pinos, 930m, *Baeza & Kottirsch 1323* (CONC); Bío-Bío. Salto del Laja, 100 m, *Emhart s.n.* (CONC); Entre Los Ángeles y Antuco, 10 km antes de Antuco, *Finot 2449* (CONC-CH); Salto del Laja, orillas del Río Laja, 100 m, *Finot 2354* (CONC-CH); Los Ángeles-Santa Bárbara, Río Duqueco, *Pfister 6187* (SGO); Antuco, 800 m, *Barros s.n.* (CONC); Antuco, Quebrada Huingán, 900 m, *Junge 6930* (CONC, SGO); Los Ángeles - Santa Bárbara, 125 m, *Pfister 6187* (SGO); Centinela, Río Claro, 80 m, *Vinet 15* (CONC); P.N. Laguna del Laja, de Los Barros a Pichachén, 1470 m, *Baeza et al. 3099* (CONC); P.N. Laguna del Laja, Ladera SE del Volcán, 1430 m, *Soreng & Soreng 7180* (CONC); Quilleco, Sector Las Animas, 370 m, *Baeza & López 1829* (CONC); Santa Bárbara, Río Duqueco, 125 m, *Pfister s.n.* (CONC); Trapatrapa, 915 m, *Rahmer s.n.* (SGO); Concepción, 10m, *Barros 117* (CONC); Concepción, Cerros de La Toma, 100 m, *Pfister 6250* (SGO); Cerros detrás de La Cantera, 100 m, *Pfister 4910* (SGO); Barrio Universitario, 50 m, *Pfister s.n.* (CONC); Caleta Burca, 5 m, *Ugarte 173* (CONC); Camino Florida, Fundo Trinitarias, 100 m, *Pfister s.n.* (CONC); Cerro Caracol, 200 m, *Gunckel s.n.* (CONC); Cerro Margarita, 90 m, *Junge 3077* (CONC); Cerros La Toma, 100 m, *Pfister s.n.* (CONC); Concepción, 10 m, *Barros 1984* (CONC); Concepción, 10 m, *López 384* (CONC); Desembocadura del Río Bío-Bío, 5 m, *Ricardi 810* (CONC); Hualpén, Playa Blanca, 20 m, *Pfister s.n.* (CONC); La Toma, 60 m, *Pfister s.n.* (CONC); La Toma, 60 m, *Junge s.n.* (CONC); Laguna Lo Galindo, 25 m, *López 740* (CONC); Lirquén, Camino Tomé, 215 m, *Pfister s.n.* (CONC); Ramuncho, 40 m, *Ricardi 541* (CONC); Ñuble, Atacalco, Río Diguillin, 650 m, *Pfister 399* (CONC); Baños de Chillán, 2000 m, *Philippi s.n.* (SGO); Camino a Pinto, Parcela El Ciprés, 280 m, *Finot s.n.*(CONC-CH); Chillán, *de Solís s.n.* (SGO); Estación Experimental El Nogal, Universidad de Concepción, 120 m, *T. Rodríguez & J. Solís s.n.* (CONC-CH); Chillán, Quilmo, 50 m, *Yuraszeck et al. s.n.* (CONC-CH); Cobquecura, 20 m, *Araya 54* (CONC); Cordillera de Chillán, Río Renegado, 950 m, *Finot et al. 404* (CONC-CH); Fundo Atacalco, 650 m, *Pfister 6278* (CONC, SGO); Ñuble, Nevados de Chillán, Pirigallo, 2000 m, *Rodríguez & A. Marticorena 3002* (CONC); Puente Queime, Laguna Turbia, 75 m, *Rodríguez 1495* (CONC); Quillón, Laguna Avendaño, 50 m, *Mazzeo et al. s.n.* (CONC); Ribera Sur del Río Itata, 25 m, *Cavieres et al. 3688* (CONC); camino Chillán-Pinto km 10, El Ciprés, 1992, *Finot s.n.* (CONC-CH); San Ignacio, Montaña Garay, 226 m, *Quintana 383* (CONC-CH); Termas de Chillán, 1850 m, *Pfister s.n.* (CONC); Termas de Chillán, 1740 m, *Pfister 6260* (CONC, SGO); Termas de Chillán, 1700 m, *Puentes s.n.* (CONC); Termas de Chillán, 2100 m, *Finot 1643* (CONC-CH); Termas de Chillán, Fumarolas, 2000 m, *Pfister 6259* (SGO). **Región de la Araucanía:** *Rahmer s.n.* (SGO); Camino de Quilquilco a Laguna Malleco, km 30, *Pfister 6196* (SGO); Cautín, 300 m, *Baeza s.n.* (CONC); Cautín, 8 km W de Paso Mamuil Malal, 1120 m, *Soreng 7141* (CONC); Cherquenco, 526 m, *Gunckel 13925* (CONC); Curarrehue, 900 m, *Cañulaf s.n.* (CONC); Galvarino, 50 m, *Demanet s.n.* (CONC); Lautaro, 205 m, *Arriagada s.n.* (CONC); Puente Loncotripai, a 15 km de Tirúa, 120 m, *Parra & Torres 767* (CONC); Puerto Saavedra, 10 m, *Montero 3711* (CONC); Puerto Saavedra, *Hollermayer 8, 208* (CONC); Río Pedregoso, 190 m, *Friedrich s.n.* (CONC); Temuco, *Gunckel 36597, 44515* (CONC); Temuco, Cerro Ñielol, *Gunckel 3920, 9761, 36529* (CONC); Toltén, 50 m, *Friedrich s.n.* (CONC); Truf Truf, 150 m, *Gunckel 17083, 28005* (CONC); Volcán Villarrica, 1300 m, *Barros 4494* (CONC); Lonquimay, Confluencia del Bío-Bío y Rahue, *Pfister 7285* (SGO); Los Lagos, Osorno, Playa Maitén, Puerto Fonk, *Ponce 25* (SGO); Angol, Lealtad, 75 m, *Kunkel 613* (CONC); Angol, Los Alpes, 25 m, *Coronel & Standen 43* (CONC); Camino Quilquilco a Laguna Malleco, km 30, 700 m, *Pfister s.n.* (CONC); Collipulli, 250 m, *Martínez s.n.* (CONC); Comunidad Maitenrehue, Los Copihues, 930 m, *Baeza & Kottirsch 1138* (CONC); Curacautín, Termas Río Blanco, 1400 m, *Montero 11149* (CONC); Lonquimay, Lolén, cerro Centinela, 1050 m, *Finot 35* (CONC-CH); Termas Río Blanco, 1400 m, *Montero 11149* (CONC); Lago Conguillío, 1000 m, *Zoellner 5269* (CONC); Liucura, Piedras Blancas, 1150 m, *Demanet s.n.* (CONC); Lonquimay, 900 m, *Pfister s.n.* (CONC); Lonquimay, 950 m, *Demanet s.n.* (CONC); Mininco, 190 m, *Schwabe 349* (CONC); Mininco, 190 m, *Montero 4033* (CONC); Pidima, Fundo Pidenco, Salto Del Huequén, 270 m, *Pfister s.n.* (CONC); Renaico, 70 m, *Gunckel 12049* (CONC); Termas de Río Blanco, 1100 m, *Pfister s.n.* (CONC); Termas de Río Blanco, 1200 m, *Montero 9970* (CONC); Pidima, Fundo Pidenco, Salto del Huequén, *Pfister 7133* (SGO); Pucón, Río Trancura, 200 m, *Hollermayer 1279* (SGO). **Región de Los Ríos:** Valdivia, Puente Río Cruces, *Gardner & Knees 6974* (CONC); Palena, Hornopirén, Puente Puñón, 150m, *Aedo 7340* (CONC); Valdivia, 10 m, *Gunckel 15725* (CONC); Valdivia, Bima, Cordillera de La Costa W de La Unión, Alerce, 900 m, *Eyerdam 10654* (SGO); Camino antiguo entre La Unión y Corral, Estero de Las Piedras, cerca de Chaihuín, *Plowman 2625* (SGO); Río Bueno, Antigual-Lago Ranco, *Ponce 144* (SGO); Valdivia, Arique, 100 m, *Gunckel 12539* (CONC); Cordillera Pelada de Chaihuín, 850 m, *Gunckel 3064* (CONC); Cordillera Pelada, El Mirador, 1250 m, *Ricardi & Matthei 5260* (CONC); Corral, 25 m, *Gunckel s.n.* (CONC); Corral, Amargos, 30 m, *Gunckel 19241* (CONC); Corral, Morro Gonzalo, 35 m, *Gunckel 15161* (CONC); Corral, Quitaluto, 450 m, *Gunckel 14876* (CONC); Corral, San Juan, 90 m, *Gunckel 1405* (CONC); Valdivia, entre Arquilhue y Llifén, 200 m, *Klempau 471* (CONC); Huidif, 150 m, *Gunckel 12644* (CONC); Isla Teja, 30 m, *Gunckel 39835* (CONC); La Barra, 3 m, *Montero 3040* (CONC); Laguna Maihue, Los Llolles, 100 m, *Marticorena & Furet 26* (CONC); Llancacura, 100 m, *Gunckel 17042* (CONC); Llancacura, entre Cancha 3 y 4, 100 m, *Schlegel 1499* (CONC); Los Guindos, 110 m, *Gunckel 12548* (CONC); Misión de Quinchilca, 125 m, *Gunckel 7214* (CONC); Niebla, 20 m, *Oehrens s.n.* (CONC); Panguipulli, 130 m, *Hollermayer 8* (CONC); Quinchilca, 60 m, *Hollermayer 1208* (CONC); Quitaluto, 600 m, *Gunckel 1452, 14524* (CONC); Reumén, Pampas de Huite, 170 m, *Montero 4106* (CONC); Riñihue, 115 m, *Kunkel 681* (CONC); San José de La Mariquina, 25 m, *Aravena 315* (CONC); Valdivia, 25 m, *Gunckel 41902* (CONC). **Región de Los Lagos:** Chiloe, Sur Ayacara, *Levi s.n.* (SGO); Alcaldeo de Llau-Llao, 100 m, *Villagrán 3754* (CONC); Camino Chacao a Ancud, entrada camino Caulín, 45 m, *Marticorena et al. 13* (CONC); Castro, 35 m, *Montero 7867* (CONC); Chepu,

40 m, *Villagrán 3359* (CONC); Entre Piruquina y Auquilda, 140 m, *Villagrán 3674* (CONC); Isla Alao, 30 m, *Villagrán & Águila 6034* (CONC); Isla Alao, 30 m, *Villagrán & Meza 5894* (CONC); Isla Alao, La Capilla, 20 m, *Villagrán & Águila 5929* (CONC); Isla Apiao, 35 m, *Meza & Águila 6390* (CONC); Isla Apiao, 35 m, *Meza 6265* (CONC); Isla Apiao, La Capilla, 3 m, *Villagrán 6288* (CONC); Isla Chaulinec, 100 m, *Villagrán & Águila 6547* (CONC), Isla Chaulinec, 40 m, *Meza & Valenzuela 5366* (CONC); Isla Chaulinec, Capilla Vieja, 25 m, *Villagrán & Águila 6057* (CONC); Isla Chuit, 5 m, *Meza & Águila 6742* (CONC); Isla Guafo, 100 m, *Villagrán & Leiva 7520, 7353* (CONC); Isla Nayahue, 10 m, *Villagrán & Águila 6678* (CONC); Isla Quilá, 25 m, *Villagrán & Leiva 7210* (CONC); Isla Talcán, *Villagrán 3484* (CONC); Isla Talcán, 17 m, *Villagrán & Águila 6242* (CONC); Isla Talcán, 30 m, *Urbina & Riffo 1208* (CONC); Lago Río Negro, 100 m, *Villagrán et al. 6963* (CONC); Manao, 20 m, *Landero 6* (CONC); Piruquina, 25 m, *Junge s.n.* (CONC); Piruquina, 150 m, *Villagrán 3944* (CONC); Rolecha, *Pfister s.n.* (CONC); Chaitén-Caleta Santa Bárbara, 25 m, *Villagrán et al. 6813* (CONC); Chuyaca, cerca de Osorno, *Rudolph s.n.* (SGO); Corral, 25 m, *Krause s.n.* (SGO); Huahuim, *O. Philippi s.n.* (SGO); Islote Rupanco, *Godoy s.n.* (SGO); Llanquihue, Puerto Varas, El Monte, *Ponce 116* (SGO; Volcán Osorno, Ensenada cerca Petrohué, *Ponce 75* (SGO); Chilcón, Lago Todos Los Santos, 180 m, *Pfister s.n.* (CONC); Peulla, 190 m, *Pfister s.n.* (CONC); Puerto Montt, 35 m, *Pfister 307* (CONC); Osorno, Playa Maitén, Puerto Fonk, *Ponce 25* (SGO); Rahue, Río Rahue, *Ponce 180* (SGO); Osorno, Fundo Centinela, Puerto Octay, 60 m, *Pisano & Geni 1139* (CONC); Osorno, Fundo Venecia, Trumao, 5 m, *Hollermayer 1250* (CONC); Lago Puyehue, 200 m, *Levi 1845, 1921* (CONC); Lago Puyehue, 1300 m, *Levi 1889* (CONC); Lago Puyehue, 250 m, *Levi 2031* (CONC); Playa Maitén, Puerto Fonk, 100 m, *Ponce 25* (CONC); Puyehue, 200 m, *Rehn 118* (CONC); Salto del Pilmaiquén, *Pisano & Geni 1220* (CONC); Trumao, Quilacoyán, 65 m, *Hollermayer 1208* (CONC); P.N. Puyehue entre Aduana y El Colorado, 420 m, *M. Muñoz & C. Muñoz 390* (SGO); P.N. Puyehue, Aguas Calientes, hacia E Pasado Cruce a Antillanca, 920 m, *M. Muñoz & C. Muñoz 567* (SGO). **Región de Aysén:** P.N. Laguna San Rafael, Lago Bayo, 160 m, *Soreng & Soreng 7271* (CONC); Aysén, 5 m, *Navas s.n.* (CONC); Coyhaique, 740 m, *Morán s.n.* (CONC); Coyhaique, cerca Villa La Tapera Sector Cisne Medio, 240 m, *Silva et al. 50* (CONC-CH); Laguna San Rafael, 100 m, *Teillier & Márquez 4327* (CONC); Los Mallines, Cerca de Balmaceda, 500 m, *Maldonado 62* (CONC); P.N. Laguna San Rafael, Río Tempanos, *Pisano 6234* (CONC); Cercanías Lago Seco, 720 m, *Schlegel 2360* (CONC); Lago Bertrand, Puerto Bertrand, 240 m, *Seki 469* (CONC); Río Romero, 640 m, *Seki 499* (CONC); Laguna San Rafael, Península de Taitao, *Espinosa s.n.* (SGO).

2. Polypogon cachinalensis Phil., Fl. Atacam. 54. 1860. (**Fig. 1**). TIPO: CHILE: ad Cachinal de la Sierra, 25° lat. m., 7000 p.s.m., legi, *Philippi 341* (HOLOTIPO: SGO-63109!).

Perennes de 5–20 cm de alto; nudos 2, glabros; vainas más cortas que los entrenudos, glabras, estriadas; lígula de 1–1,5 mm de largo, hialina, truncada, escabrosa en el dorso; láminas de 0,7–2 cm de largo, 1–1,5 mm de ancho, escabrosas. Panícula de 1,2–2,3 cm de largo, 0,4–0,5 cm de ancho, espiciforme, purpúrea; raquis glabro. Espiguillas de 1,3–2 mm de largo, se desprenden con un fragmento de pedicelo de 0,2 mm de largo; pedicelos breves, hirsutos; glumas de 1,3–2 mm, purpúreas, bilobadas en el ápice, los márgenes del ápice ciliados, aristadas subapicalmente, la arista brevísima (0,3–0,5 mm); lemma de 1,3 mm de largo, mútica, hialina, brillante, truncada, los nervios extendidos en 4 arístulas brevísimas; callo glabro; pálea de 1,1 mm de largo, hialina, bidentada, poco más corta que la lemma; lodículas 2, de 0,5 mm de largo, lineares, el ápice redondeado; anteras de 0,5 mm de largo. Cariopsis obovoídea, de 1 mm de largo.

Fenología.—Florece y fructifica en enero.

Distribución geográfica y hábitat.—Endémica de Chile, conocida entre las regiones de Antofagasta y Coquimbo. Crece en sectores de vegas y orillas de cursos de agua entre los 2600 y los 3000 m de altitud por la Cordillera de Los Andes.

Material adicional estudiado.—**CHILE. Región de Coquimbo:** Cordillera de Combarbalá, Potrero Grande, 2700–2800 m, *Jiles 4824* (CONC); Cordillera de Combarbalá, hacienda Ramadilla, 2600 m, *Jiles 4831* (CONC); Cordillera de Ovalle, San Miguel, 3000 m, *Jiles 3633* (CONC).

3. Polypogon chilensis (Kunth) Pilg., Repert. Spec. Nov. Regni Veg. 16:386. 1920. *Chaetotropis chilensis* Kunth, Revis. Gramin. 1:271, t. 47. 1830. TIPO: Crescit in regne Chilensi, *d'Urville* (SINTIPO: P no visto; ISOSINTIPO; BAA no visto).

Vilfa muricata J. Presl., Reliq. Haenk. 1(4–5):240. 1830. *Agrostis muricata* (J. Presl) Kunth, Enum. Pl. 1(1):219. 1833. TIPO: PERÚ: in montanis Peruviae huanoccensibes, Haenke s.n. (HOLOTIPO: PR no visto; ISOTIPO: US fragm. ex PR no visto).

Agrostis pectinata Hack. & Arechav., Anales Mus. Nac. Montevideo 1(4):347, t. 36. 1896. TIPO: URUGUAY: terrenos arenosos y húmedos, orillas de arroyos, lagunas, etc. (LECTOTIPO: designado aquí, *Arechavaleta s.n.*, en terrenos arenosos y húmedos, US-843553 imagen internet!).

Chaetotropis latifolia Phil., Linnaea 30(2):205. 1859. TIPO: CHILE: loco Ilque dicto, haud procul a Puerto Montt inveni. (HOLOTIPO: SGO-37105!; ISOTIPOS: BAA-3509 fragm. y dibujo, imagen internet!; BAA-3510 fragm. y dibujo, imagen internet! HAL-105144 imagen internet!, SGO-63148!, US-1939361-fragm. ex SGO-37105 & imagen internet!).

Anuales; cañas de 40–86 cm de alto; entrenudos de 13–24 cm de largo, glabros, estriados; nudos 2–4, glabros, castaños. Vainas de (6–)10–17(–23) cm de largo, más cortas que los entrenudos, glabras; lígulas membraná-

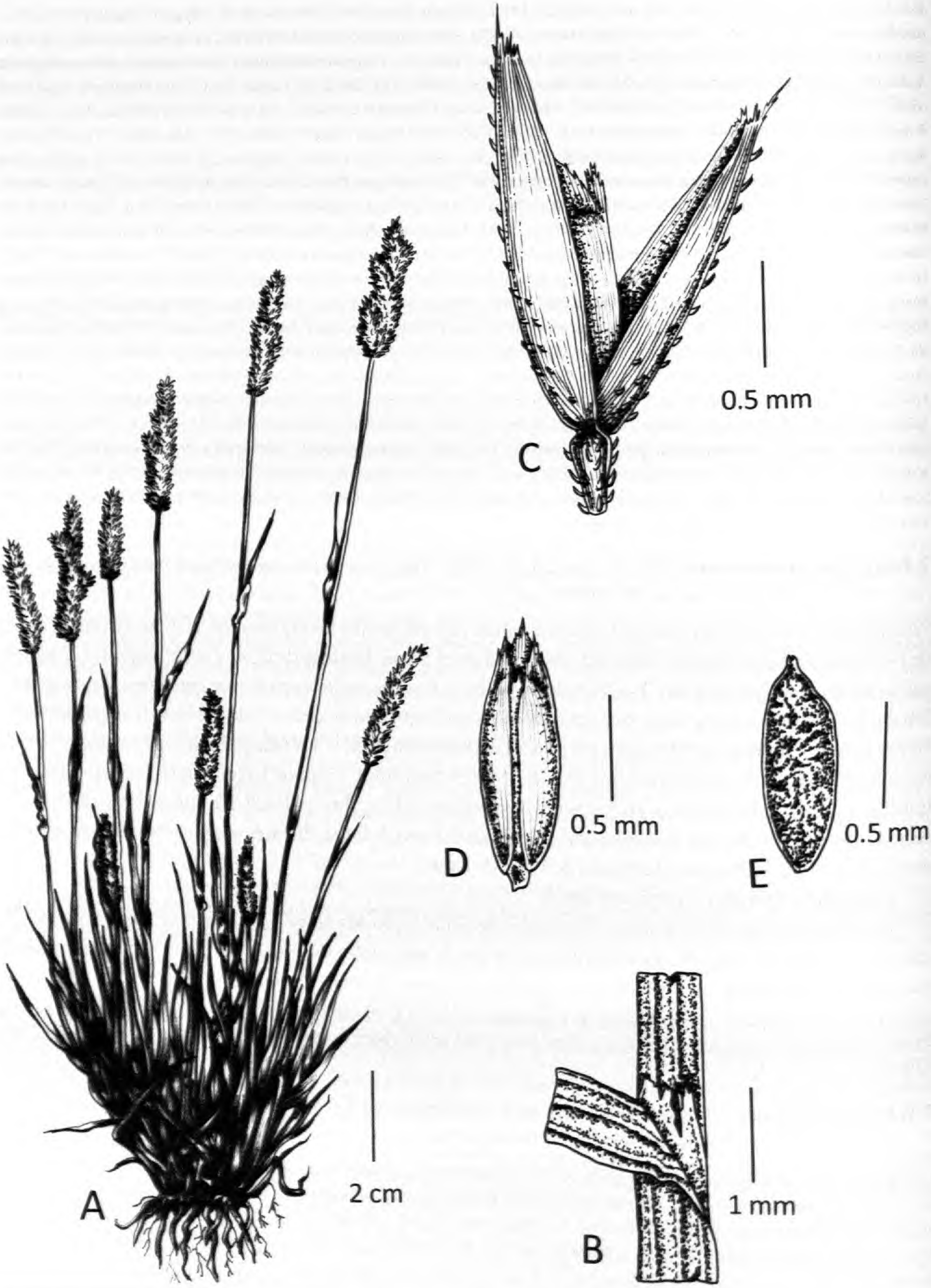


FIG. 1. *Polypogon cachinalensis* Phil. (*Jiles 4831*). **A.** Hábito. **B.** Lígula. **C.** Espiguilla. **D.** Lemma, vista vetral. **E.** Cariopsis, vista lateral.

ceas, de 2,5–5 mm de largo, glabras o algo escabrosas en la cara abaxial, denticuladas en el ápice; láminas de 11–17(–25) cm de largo por 3–5 mm de ancho, planas, glabras o suavemente escabrosas en ambas caras, bordes escabrosos. Panículas espiciformes, ápice lobulado, amarillentas o verde pálido no violáceas, de (6–)9–16 cm de largo por 1–3 cm de ancho, con ramas laterales de 2–4 cm de largo, contraídas o laxas; raquis glabro o escabriúsculo. Espiguillas se desprenden con un fragmento de pedicelo de 0,5–2 mm de largo; pedicelos de 0,5–2,3 mm de largo, fuertemente escabrosos; glumas subiguales de 2–2,6 mm de largo por 0,3–0,6 mm de ancho, a veces la gluma inferior levemente más larga que la superior, la quilla provista de escabrosidades de 0,2–0,5 mm de largo, el ápice agudo, mucronado; lemmas de 1,2–1,7 mm de largo, glabras, hialinas, ápice truncado, 4-aristulado, las 2 arístulas externas más largas que las internas; arista ausente o presente, recta o levemente geniculada, de 0,5–1,2 mm de largo, subapical, inserta a 0,3 mm del ápice, exserta o no entre las glumas; pálea de 0,4–0,8 mm de largo, menor que la mitad lemma, hialina; callo glabro; lodículas de ca. 0,4 mm de largo; anteras de 0,4–0,6 mm de largo. Cariopsis de 0,9–1,5 mm de largo por 0,2–0,4 mm de ancho.

Iconografía.—Nicora (1978: 400, fig. 266a-e bajo *Chaetotropis chilensis*); Rúgolo (2012a:166 bajo *Ch. chilensis*); Rúgolo et al. (2008: 18: fig. 3a-c).

Fenología.—Florece entre octubre y febrero.

Distribución geográfica *y hábitat*.—Especie americana, distribuida en Argentina, Brasil, Chile, Paraguay y Uruguay (Soreng et al. 2003; Rúgolo et al. 2008). En Chile se extiende desde la Región de Atacama hasta la región de Los Lagos (Isla grande de Chiloé). Se encuentra también en el Archipiélago de Juan Fernández (Isla Robinson Crusoe), donde fue probablemente introducida en el s. XVII (Skottsberg 1921). Habita principalmente zonas costeras o precordilleranas de baja altura, desde el nivel de mar hasta los 700 m de altitud, en suelos arenosos y húmedos. Especie muy común en praderas, considerado un forraje apetecido aunque de bajo rendimiento (Rosengurtt et al. 1970).

Caracteres distintivos.—Se caracteriza por la presencia de escabrosidades de 0,2–0,5 mm de largo en el dorso de las glumas (½ del ancho de las glumas a tan largas como el ancho de las glumas); las glumas son agudas o mucronadas, carecen de una arista desarrollada; la lemma puede ser mútica o bien presentar una arista dorsal de hasta 1,2 mm de largo.

Especímenes adicionales examinados.—**ARGENTINA. Buenos Aires:** Las Palmas, *A.Burkart 17550* (SI). **Entre Ríos:** Gualeguaychú, Brazo Largo, *E. Nicora 2381* (SI); Isla del Francés, frente a Rosario, *A.Burkart 8851* (SI). **Yapeyú:** Yapeyú, *A.Burkart 7876* (SI). **Santa Fe:** Vera, Fortín Chilcas, cerca de la laguna el Barco, *Lewis & Pire 579* (SI). **CHILE. Región de Atacama:** Huasco, acceso sur a Vallenar, *Matthei & Rodríguez 122* (CONC). **Región de Valparaíso:** Archipiélago de Juan Fernández, Isla Robinson Crusoe, Puerto Francés, en las rocas litorales, 100 m, *Sparre 103* (CONC); Archipiélago de Juan Fernández, Isla Robinson Crusoe, between the electric generating plant and the main street (Larraín Alcalde), *Rondanelli & Humaña 11499* (CONC); Archipiélago de Juan Fernández, Isla Robinson Crusoe, Down from Damajuana into Quebrada Corrales de Molina, 300 m, *Stuessy et al. 15105* (CONC); Archipiélago de Juan Fernández, Isla Robinson Crusoe, from La Punta (near Airport) to Villagra on the road, 260 m, *Baeza et al. 11710* (CONC); Archipiélago de Juan Fernández, Isla Robinson Crusoe, Quebrada de El Inglés, 400 m, *C. Muñoz & E. Sierra 7333* (CONC); Archipiélago de Juan Fernández, Isla Robinson Crusoe, Cerro Agudo, 5th Quebrada, 640 m, *Stuessy & Soto 11939* (CONC). **Región del Bío-Bío:** Concepción, Hualpén, Parque Pedro del Río, 150 m, *H. Gunckel s.n 12890, 12905* (CONC). **Región de Los Ríos:** Valdivia, Puñire, 450 m, *Hollermayer s.n.* (CONC). **Región de Los Lagos:** Chiloé, Isla Grande de Chiloé, Huildad, 100 m, *Villagrán 4899* (CONC). **URUGUAY. Flores:** Río Yi y Arroyo Matanzas, *Rosengurtt B-580* (CONC). **San José:** Barra Santa Lucía, 10 m, *Herter 333a* (CONC).

4. Polypogon elongatus Kunth, Nov. Gen. Sp. (quarto ed.) 1:134–135. 1816.

4a. Polypogon elongatus Kunth var. **elongatus**[1]. *Alopecurus elongatus* (Kunth) Poir., Encycl. 5:495. 1817. *Chaetotropis elongata* (Kunth) Björkman, Symb. Bot. Upsal. 17(1):14. 1960. Tipo: ECUADOR: Crescit in temperatis regni Quitensis prope Chillo, alt. 1350

[1]**La revisión del género nos permitió reconocer el siguiente taxón dentro de *Polypogon*, que no se encuentra presente en Chile y para el cual se establece la siguiente combinación:**

Polypogon elongatus Kunth var. **longearistatus** (Nicora) Finot, comb. nov. *Chaetotropis elongata* var. *longearistata* Nicora, Fl. Prov. Buenos Aires 4(2):208. 1970. Tipo: ARGENTINA: Buenos Aires, Anchorena, orillas del río de La Plata, 4 oct 1959, *Boelcke 8667* (holotipo: BAA-3501 imagen internet!; isotipo: SI-661656 fragm. ex BAA imagen internet!).

Zuloaga et al. (2008) y Rúgolo (2012a) aceptan esta variedad bajo *Chaetotropis*. Otros autores la consideran un sinónimo de *P. elongatus* (Soreng et al. 2003). Se distingue de la variedad típica por su panícula laxa, las espiguillas largamente pediceladas, las glumas largamente aristadas (aristas de hasta 6 mm de largo), las lemmas de 2–2.8 mm de largo (1.5–2 mm en la variedad típica), arista de la lemma de 3–4,5 mm (1–3 mm en la variedad típica).

Distribución geográfica.—Argentina (Buenos Aires) y Uruguay.

hexap. ubi pecus hujus plantae valde appetens est, *Humboldt & Bonpland* s.n. (HOLOTIPO: P-669393 imagen internet!; ISOTIPO: P-135063 imagen internet!).

Polypogon intermedius Carmich. Trans. Linn. Soc. London 12:504. 1819. TIPO: Island of Tristan da Cuhna (HOLOTIPO: P no visto; ISOTIPO: US-fragm. ex P no visto).

Polypogon inaequalis Trin., Gram. Panic. 24. 1826. TIPO: V. sp Brasilia, *Langnsdorff* (HOLOTIPO: LE-TRIN-1565.07a no visto; ISOTIPO: US-999294-fragm. ex LE-TRIN no visto).

Polypogon affinis Brongn., Voy. Monde 2:19. 1829. TIPO: CHILE: La Conception du Chili (HOLOTIPO: P?).

Raspailia agrostoides J. Presl., Reliq. Haenk. 1(4–5):239, t. 40. 1830. *Nowodworskya agrostoides* J.Presl, Reliq. Haenk. 1:351, t. 80. 1830. TIPO: PERÚ: Habitat in Peruviae montanis huanoccensibus, *Haencke* s.n. (HOLOTIPO: PR no visto; ISOTIPOS: HAL-107134 fragm. imagen internet!; LE-TRIN-1565.03 no visto, MO-2097123 imagen internet!, US-fragm. ex PR no visto, US-fragm. ex B no visto).

Polypogon mexicanus Hort. ex Steud., Syn. Pl. Glumac. 1:185. 1855. TIPO: Cult. Hort. Halens. 1842 from: México. Cites Hort. Halens (1842. non Spr.) [nom. inval.].

Plantas perennes, erguidas; cañas de 50–85 cm de alto; entrenudos de 8–14 cm de largo, glabros; 2–3 nudos, glabros. Vainas de 6–13 cm, más cortas o tan largas como los entrenudos, glabras; lígulas hialinas, de 3–6 mm de largo, glabras, con el ápice denticulado; láminas de (7–)10–17 cm de largo, 3–6 mm de ancho, planas, escabrosas en ambas caras. Panículas laxas, lobuladas, interruptas, verde pálido con tonos amarillentos, de 8–18 cm de largo, 1,5–3 cm de ancho; raquis escabroso. Espiguillas se desprenden con el pedicelo casi completo de 2–4 mm de largo; pedicelos de 2–4,5 mm de largo, escabrosos; glumas escabrosas en el dorso, la inferior de 1,8–3,2 mm de largo, la superior de 1,4–2,8 mm de largo excluidas las aristas, 0,4–0,6 mm de ancho, aristadas desde el ápice, la arista de 0,8–1,8 mm de largo, recta, escabrosa; lemmas de 1,5–2,2 mm de largo, glabras, hialinas, brillantes, ápice truncado, arista de 1,3–3 mm de largo, subapical (inserta a 0,3–0,5 mm del ápice), recta, escabrosa; pálea de 0,5–0,9(–1,3) mm de largo, ca. ½ de la longitud de la lemma, membranácea; callo glabro; lodículas de 0,5 mm de largo, agudas; anteras de 0,4–0,6 mm de largo. Cariopsis lisa, de 1–1,8 mm de largo, 0,3–0,5 mm de ancho, elipsoidal; surco ventral largo.

Iconografía.—Doell & Hackel (1895: Tab. XI); Hitchcock (1951; 365, fig. 514); Nicora (1978: 400, fig. 268a-f bajo *Chaetotropis elongata*); Tovar (1993: 197, fig. 21 h-i).

Fenología.—Florece desde noviembre a marzo.

Número cromosómico.—2n = 24, 56 (Pohl & Davidse 1971).

Distribución geográfica y hábitat.—Argentina, Bolivia, Brasil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, México, Nicaragua, Panamá, Perú, USA, Uruguay y Venezuela (Hitchcock 1927; Soreng et al. 2003). En Chile se encuentra desde la Región Metropolitana hasta la Región del Bío-Bío. Habita zonas de baja montaña desde los 400 a los 850 m de altitud, principalmente en suelos húmedos. Ha sido citada como planta introducida en Europa (Alemania, Bélgica, Francia) (Thellung 1912).

Caracteres distintivos.—Se caracteriza por sus espiguillas con glumas subuladas, que se desprenden con un artejo que comprende casi todo el pedicelo.

Observación.—El protólogo de *P. affinis* Brongn. indica como localidad tipo, "La Conception du Chili" sin mencionar el colector. Brongniart comenta que la especie es muy cercana a "*P. elongatum*" (*P. elongatus*), de la que, en su opinión, difiere por las aristas de las glumas más cortas, por la pequeñez de la pálea, apenas más larga que las lodículas y que podría se confundida por una tercera lodícula. Desvaux (1854) acerca también *P. affinis* Brongn. a *P. elongatus* y lo trata como sinónimo de esta especie. Robert Soreng (Smithsonian Institution, com. pers.), sugiere que el tipo de *P. affinis* fue probablemente recolectado por Desmont d'Urville o al menos bajo su supervisión. Bajo *P. affinis*, París (P) (http://sonneratphoto.mnhn.fr/2011/03/30/1/P02277858.jpg) muestra dos ejemplares. Uno de ellos (P 2277858) lleva en etiqueta la siguiente información "In arenosis sterilibus secus torrentes, ad pratorum margines, fossas, in herbidis udis Rancagua, Quillota, Chili, Octbr. 1828, Hrbr. Bertero 273 (sub *Festuca* an *Polypogon*) 566. 1254, 1256 et 1497 (ex Ins. Juan Fernández)". El otro ejemplar es probablemente cultivado y fue recolectado por Buchtien en 1860 (P 2332396). El ejemplar Bertero 273 es probablemente el material original en que se basó la descripción de la especie. Un dibujo de Trinius en que incluye un espécimen de Perú y el ejemplar *Bertero* 273 muestra espiguillas que sugieren que *P. affinis* es un sinónimo de *P. elongatus* como sugiere Desvaux (1854) y no de *P. chilensis* (Soreng et al. 2003).

Especímenes adicionales examinados.—**ARGENTINA. Córdoba:** *A. Castellanos 469* (SI); Pampa de Achala, *A. Burkart 10171* (SI). **Jujuy:** Capital, Camino de Laguna de Yala a termas de Reyes, *Zuloaga & Deginami 3424* (SI); Capital, Quebrada de Yala, *Cabrera et al. 31552* (SI); Sierra de Zapla, *Cabrera et al. 32015* (SI). **La Rioja:** cerro Famatina, Guanchín Viejo, *Castellanos s.n.* (BA). **Mendoza:** arroyo antes de Lespallata, *Nicora 4419* (SI); Pareditas, *Burkart et al. s.n* (SI); Salta, Caldera, camino de Cornisa a Jujuy, *Cabrera 27296* (SI). **San Juan:** Calingasta, potrero de las Burras, *Kiesling et al. 7376* (SI). **CHILE. Región Metropolitana:** Santiago, cerro San Cristóbal, 1878, *Mayi s.n* (SGO); El Canelo, cajón del Maipo, 843 m, 1953, *Navas s.n.* (CONC); Río Clarillo, 700 m, *Araya 68, 69, 88* (CONC). **Región del Bío-Bío:** Ñuble, Cobquecura, *Finot & Solís 2288* (CONC-CH). **MÉXICO. Chihuahua:** presa de Chihuahua, *Lesueur 150* (BA). **PERÚ. Huánuco:** Km 454 on Lima- Tingo Maria road, *Young & G.Sullivan 604* (SI).

CLAVE DE LAS VARIEDADES DE *P. ELONGATUS* PRESENTES EN CHILE

1. Panículas laxas, lobuladas, no espiciformes; lemma aristada; láminas de 7–15 cm de largo por 2,5–5 mm de ancho, escabrosas; lígula glabra _____ var. **elongatus**
1. Panículas contraídas, espiciformes o subespiciformes; lemma mútica; láminas de 5–6 cm de largo, 1–2,5 mm de ancho, glabras; lígula glabra o menos frecuentemente escabrosa _____ var. **strictus**

4b. Polypogon elongatus Kunth var. **strictus** E. Desv., Fl Chil. 6:302. 1854. (**Fig. 2**). TIPO: CHILE: Santiago, *Gay s.n.* (HOLOTIPO: SGO 37180 imagen internet!).

Se distingue de la variedad típica por tener panículas compactas, de (2,5)5–8 cm de largo, 0,8–2 cm de ancho y lemma mútica. Las plantas son generalmente pequeñas, menores de 35 cm de alto.

Fenología.—Florece desde diciembre a febrero.

Distribución geográfica y hábitat.—Se encuentra especialmente en el sur de Chile. Crece entre Santiago y la Región Los Lagos (Isla Grande de Chiloé), entre 5 m y 200 m de altitud, en suelos húmedos, a veces arenosos.

Especímenes adicionales estudiados.—**CHILE. Región de Los Ríos:** Valdivia, Corral, La Rama, 6 m, *Gunckel 40920* (CONC); Chaihuin, 200 m, *Gunckel 40662* (CONC); Niebla, 20 m, 1931, *Gunckel s.n.* (CONC). **Región de Los Lagos:** Chiloé, entre caleta Santa Bárbara y Chana, 5 m, *Villagrán et al 7095* (CONC); isla Quilán, 25 m, *Villagrán & A. Leiva 7225* (CONC); isla Refugio, 30 m, *Villagrán & A. Leiva 7385* (CONC); isla Surgidero, 30 m, *Villagrán & A. Leiva 7462* (CONC).

5. Polypogon exasperatus (Trin.) Renvoize, Gram. Bolivia 235. 1998.

5a. Polypogon exasperatus (Trin.) Renvoize var. **exasperatus.** *Agrostis exasperata* Trin., Mem. Acad. Imp. Sci. Saint-Petersbourg, Ser. 6, Sci. Math., Seconde Pt. Sci. Nat. 6,4(3–4):352. 1841. *Chaetotropis exasperata* (Trin.) Björkman, Symb. Bot. Upsal. 17(1):14. 1960. TIPO: CHILE: Concepción, *d'Urville s.n.* (HOLOTIPO: LE-TRIN-1608.01 fragm. ex hb. Kunth, no visto; ISOTIPOS: B-W, US-75328 fragm. ex LE-TRIN1608.01 no visto).

Agrostis asperigluma Steud., Syn. Pl. Glumac. 1:422. 1854. *Chaetotropis asperigluma* (Steud.) Nicora, Fl. Patagonica 8(3):402. 1978. TIPO: CHILE: pr. Huiti in pascuis, Jan, *W. Lechler 758* [HOLOTIPO: P no visto; ISOTIPOS: BAA 3512 fragm. ex P imagen internet!, K-3084885 imagen internet!, US-75327 fragm. ex P imagen internet!).

Vilfa acutiglumia Steud. ex Lechler, Berberid. Amer. Austr. 56. 1857. TIPO: PERÚ: *Lechler 1542*. nom. nud.

Agrostis patagonica Phil., Linnaea 29(1):88. 1858. TIPO: ARGENTINA: Río Negro, ex expeditione ad lacum Nahuel Huapi, *Fonck s.n.* (HOLOTIPO: SG0-PHIL-165!; ISOTIPOS: BAA-4207 fragm. ex SGO-45510 imagen internet!, SGO-45510!, US-556337 fragm. ex SGO-PHIL-165, US-foto ex SGO-45510).

Chaetotropis araucana Phil., Anales Univ. Chile 94:17. 1896. TIPO: CHILE: in Araucaniae pratis montosis. Loco dicto Rucapillan legi (HOLOTIPO: SGO-PHIL-194; ISOTIPOS: BAA-1705, dibujo y fragm. ex SGO imagen internet!, SGO-37106!, SGO-63127!

Agrostis exasperata var. *viridis* Kuntze, Revis. Gen. Pl. 33:339. 1898. TIPO: CHILE: 2100 m. Paso Cruz, *O. Kuntze s.n.*(Isotipos: BAA no visto, LP no visto).

Agrostis santacruzencis Speg., Anales Mus. Nac. Buenos Aires 7:187. 1902. TIPO: ARGENTINA: Santa Cruz, Febr. 1882 *C. Spegazzini* LPS-2545 (HOLOTIPO: LPS-2545 imagen internet!; ISOTIPOS: BAA-27 imagen internet!, LP-6810 probable isotipo, imagen internet!, US-1818805].

Agrostis hackelii R.E. Fr., Nova Acta Regiae Soc. Sci. Upsal. 1:175, t. 9, f. 9–11. 1905. *Chaetotropis hackelii* (R.E. Fr.) Björkman, Symb. Bot. Upsal. 17(1):14. 1960. *Polypogon hackelii* (R.E. Fr.) Renvoize, Gram. Bolivia 236. 1998. TIPO: ARGENTINA: Prov. Jujuy, Cochinoca in paludibus, ca. 3300 m.s.m., 10 Feb 1901, *Kurtz 11632* (HOLOTIPO: S imagen internet!; ISOTIPOS: CORD-1442 imagen internet!, CORD-1443 imagen internet!, CORD-1444 imagen internet!, US-75317 fragm. ex S imagen internet!, US- 1126783 fragm. ex W no visto).

Agrostis hackelii fo. *viridiflora* Hack., Anales Mus. Nac. Buenos Aires 13:474. 1906. TIPO: ARGENTINA: Tucumán, Depto. Tafí, en prados húmedos y en las márgenes de los arroyos por los bosques de Aliso de la Ciénaga, 2500 m, *M. Lillo 3612*, Herb. Stuckert 15392 (ISOTIPOS: BAB-201 fragm, imagen internet!, LIL-40737 imagen internet!, SI-61480 imagen internet!).

Agrostis haenkeana Hitchc., Contr. U.S. Natl. Herb. 24(8):381. 1927. *Agrostis mucronata* J. Presl, Reliq. Haenk. 1–(4–5):238. 1830. TIPO:



Fig. 2. *Polypogon elongatus* Kunth var. *strictus* E. Desv. (*Villagrán & Leiva 7385*). **A.** Hábito. *Polypogon elongatus* var. *elongatus* (*Navas s.n.*). **B.** Espiguilla. **C.** Lemma, vista ventral. **D.** Cariopsis, vista ventral

PERÚ: *Haenke s.n.* [HOLOTIPO: PR no visto; ISOTIPOS: S-G264 fragm. ex PR, US-75316 fragm. ex PR; Paratipo: BAA-4253 imagen internet!).

Agrostis speeiana Mez, Repert. Spec. Nov. Regni Veg. 18(1–3):3. 1922. TIPO: CHILE: Coral bei Valdivia, *H. Krause s.n.*.(LECTOTIPO: B, designado por Rúgolo & Molina, Parodiana 7:196. 1992; ISOLECTOTIPO: BAA-4220 fragm. ex B, no visto).

Perennes, cespitosas, a veces con breves rizomas; cañas de 28–75(–105) cm de alto, erectas; entrenudos de 7–15 cm de largo, glabros; nudos 2–3 (–4), glabros, castaños. Vainas de 6–13 cm de largo, más cortas que los entrenudos, glabras o levemente escabrosas; lígulas membranáceas, de 0,5–1,5(–4) mm de largo, truncadas a redondeadas en el ápice, escabrosas en el dorso; láminas planas, raramente conduplicadas, de (5–)8–15 cm de largo por 1,5–3,5(–6,5) mm de ancho, escabrosas en ambas caras. Panículas laxas, de 4,5–11(–17) cm de largo por 1–4 cm de ancho, ramas laterales contraídas o laxas, verdes o violáceas, culmos escabrosos o glabros por debajo de la inflorescencia; raquis escabrosos o lisos. Espiguillas se desprenden con un fragmento de pedicelo de 0,5–2,3 mm de largo; pedicelos de 1–4,0 mm de largo, densamente escabrosos; glumas subiguales, de (2,1–)2,7–3,6 mm de largo por 0,4–0,6 mm de ancho, verdes, doradas o violáceas, no aristadas, con el ápice agudo o con un pequeño mucrón de 0,2–0,4 mm de largo, la quilla equinulada y el dorso escabroso; lemmas de 1–2 mm de largo, generalmente menor que ½ del largo de las glumas, 5-nervia, hialina, opaca, glabra, con el ápice agudo o truncado en el que sobresalen o no brevemente los nervios a modo de arístulas de igual tamaño; arista subapical, recta o geniculada, fácilmente caediza, de (0,7–)1,5–2,3 mm de largo, exserta; callo difícil de separar de la raquilla, con 3–5 pelos tiesos a cada lado o glabro; pálea de 0,4–0,8 mm de largo, hialina; lodículas agudas, de 0,5–0,7 mm de largo, anteras de 0,5–0,8 mm de largo; flores probablemente cleistógamas con anteras vacías secas adheridas al fruto. Cariopsis ovoide lanceolada o elipsoide, de 0,8–1,3 mm de largo por 0,3–0,4 mm de ancho; hilo de 0,9 mm de largo; embrión de ⅙ del largo de la cariopsis.

Iconografía.—Nicora (1978: 396, fig. 265a-e bajo *Agrostis exasperata*); Nicora (1978: 400, fig. 269a-e bajo *Chaetotropis asperigluma*); Rúgolo & Molina (1997a: 136, fig. 5J-l bajo *A. exasperata*); Rúgolo (2012a: 165 bajo *Ch. asperigluma*); Rúgolo (2012a: 168 bajo *Ch. hackelii*).

Fenología.—Florece y fructifica entre enero y marzo.

Distribución geográfica y hábitat.—Argentina, Bolivia, Chile y Perú (Soreng et al. 2003). En Chile se encuentra desde la Región del Maule, hasta la Región de Los Lagos, desde los 5 m de altitud en las zonas costeras, hasta los 2250 m en zonas montañosas; crece en suelos preferentemente húmedos arenosos o rocosos.

Caracteres distintivos.—Panículas laxas; raquis escabroso; glumas múticas, de ápice agudo o mucronado; lemma aristada; callo difícil de separar de la raquilla, con 3–5 pelos tiesos a cada lado o glabro.

Especímenes adicionales examinados.—**CHILE. Región del Maule:** Curicó, camino Laguna Teno a Paso Vergara Km 7, 2250 m, *Marticorena & Matthei 979* (CONC); Río Morinano, Baños del Azufre, 2100 m, *Barrientos 2087* (CONC); Potrero Grande, 1000 m, *Barros 1686* (CONC); Talca, Curepto, 10 m, *Barros 641* (CONC). **Región del Bío-Bío:** Malleco, Angol, P.N. Nahuelbuta, entre el centro del parque y Laguna de las Totoras, 1250 m, *Ricardi et al. 1918* (CONC). **Región de la Araucanía:** Cautín, Volcán Llaima, 1600 m, *Hollermayer 349* (CONC); Malleco, Angol, P.N. Nahuelbuta, 1200 m, *Montero 7130* (CONC); Laguna Malleco, 940 m, *Pfister s.n.* (CONC); Laguna Malleco, 900 m, *Pfister s.n.* (CONC); Lonquimay, 1680 m, *Pfister s.n.* (CONC). **Región de Los Ríos:** Valdivia, Panguipulli, 130 m, *Hollermayer 9* (CONC); Puñire, 450 m, 1928, *Hollermayer s.n.* (CONC); Quitaluto, 450 m, *Gunckel 2157* (CONC); Osorno, Lago Puyehue, Isla Fresia, 850 m, 1954, *Levi 1742* (CONC). **Región de Los Lagos:** Chiloé, trayecto caleta Santa Bárbara y Chana, 5 m, *Villagrán et al. 7080* (CONC); Llanquihue, Maullín, Las Chilcas, 25 m, *Klenner s.n.* (CONC); Puerto Varas, Fundo Gallardo, 100 m, *Ponce 82* (CONC); Puerto Montt, 35 m, *Pfister 306*, *Pfister s.n.* (CONC).

CLAVE PARA LAS VARIEDADES DE *POLYPOGON EXASPERATUS* PRESENTES EN CHILE

1. Glumas múticas o mucronadas, mucrón de hasta 0,7 mm de largo _____ var. **exasperatus**
1. Glumas aristadas; arista de hasta 1,5 mm de largo _____ var. **kuntzei**

5b. Polypogon exasperatus var. **kuntzei** (Mez) Finot, comb. et stat. nov. *Agrostis kuntzei* Mez, Repert. Spec. Nov. Regni Veg. 17(19–30):300. 1921. TIPO: CHILE: Paso Cruz, 34°, 2100 m, Jan 1892, *O. Kuntze 42* (ISOTIPOS: NY 327670 imagen internet!, 327671 imagen internet!).

Agrostis exasperata var. *purpurascens* Kuntze, Revis. Gen. Pl. 33:339. 1898. TIPO: CHILE: Paso Cruz, 2100 m, 34°, *O. Kuntze I-92* (LECTOTIPO, designado aquí: NY-327669 imagen internet!, ISOLECTOTIPOS: NY-327668 imagen internet! US-75951 foto ex NY imagen internet!, US-75952 foto ex NY imagen internet!).

Se distingue de la variedad típica por las glumas aristadas; aristas de 0,8–1,6 mm de largo (glumas agudas o mucronadas en var. *exasperatus*).

Iconografía.—Rúgolo & Molina (1977a; 143, fig. 12a-e bajo *Agrostis kuntzei*).

Distribución geográfica y hábitat.—Argentina y Chile (Soreng et al. 2003). En Chile presenta una distribución reducida a la Región de Coquimbo. Habita principalmente zonas de alta montaña entre los 2000–2800 m de altitud, generalmente en suelos húmedos.

Observaciones.—Se eligió como lectotipo el espécimen NY-327669 que contiene 7 inflorescencias completas y un dibujo interpretativo de la espiguilla, lemma, pálea, ovario y antera.

Especímenes adicionales examinados.—**ARGENTINA. Catamarca:** Belén, laguna Blanca, 3200 m, *Gómez-Kopta* 72 (SI). **Mendoza:** Puente del Inca, *Troncoso s.n.* (SI). **San Juan:** Zonda, estancia Maradona, Agua Pinto, 2300 m, *Kiesling et al. 6017* (SI). **CHILE. Región de Coquimbo:** Choapa, cordillera de Illapel, Hierba Loca, 2800 m, *Jiles 4209* (CONC); cordillera de Ovalle, La Hualtata, 2400 m, *Jiles, s.n.* (CONC); Limarí, cordillera de Ovalle, La Hualtata, 2500 m, *Jiles 1184-a* (CONC).

6. Polypogon imberbis (Phil.) Johow, Est. Fl. Islas de Juan Fernández 136. 1896. *Nowodworskya imberbis* Phil., Anales Univ. Chile 43:562. 1873. *Chaetotropis imberbis* (Phil.) Björkman, Symb. Bot. Upsal. 17(1):14. 1960. Tipo: Hallé esta grama en la isla de Juan Fernández a orillas del mar en el Puerto del Inglés, *Philippi s.n.* (holotipo: SGO-PHIL no visto; isotipo: US-95294 fragm. ex W ex SGO-PHIL imagen internet!, SGO-63114).

Agrostis tehuelcha Speg., Anales Mus. Nac. Hist. Nat. Buenos Aires 7:186. 1902. Sintipos: ARGENTINA: Santa Cruz, in uliginosis secus Río Santa Cruz, Feb 1882, *C. Spegazzini 2546* (Lectotipo, designado aquí: LP-5370 imagen internet!; Isolectotipo: US-1818806 (ex LP) imagen internet!)].

Polypogon elongatus f. *minor* Hack., Anales Mus. Nac. Buenos Aires 21:94. 1911. Tipo: ARGENTINA: Buenos Aires, 1903, *Lillo 8419 [hb. Stuckert no. 19801]* (holotipo: W no visto; isotipo: US-fragm. ex W no visto).

Polypogon elongatus var. *muticus* Hack., Anales Mus. Nac. Buenos Aires 21:94. 1911. Tipo: ARGENTINA: Prov. Buenos Aires: Mar del Plata: Estancia Chapa- Malal, *M. Estrada [hb. Stuckert 17452]*. holotipo: Argentina: Prov. Buenos Aires, Estancia Chapadmalal, Mar del Plata, 15-II-1907, *M. Estrada [hb. Stuckert 17452]* [HT: W no visto; isotipos: CORD-1838 imagen internet!, US-fragm. ex W no visto).

Polypogon imberbis f. *aristata* Skottsb., Nat. Hist. Juan Fernández 2:100. 1922. Tipo: CHILE: Juan Fernández Islands, Isla Alejandro Selkirk, Playa Ancha, 12 Mar 1917, *Skottsberg 1109* [probable holotipo: S, no visto].

Polypogon rioplatensis Herter, Revista Sudamer. Bot. 6(5–6):140, f. 9. 1940. *Chaetotropis rioplatensis* (Herter) Björkman, Symb. Bot. Upsal. 17(1):14. 1960. Tipo: URUGUAY: Montevideo, Malvin, Dec 1925, *Herter s.n.* (Sintipo: B no visto; Isosintipo: US-1341869 no visto). URUGUAY: Montevideo, *Schroeder s.n.* (Sintipo: B no visto).

Polypogon rioplatensis f. *elegans* Herter, Revista Sudamer. Bot. 6(5–6):140. 1940. Tipo: URUGUAY: Dep. San José, Arroyo San José, 10 m, aren. hum soli exp in ripariis, Dec 1930, *333d* (lectotipo, designado aquí, US-1341869 imagen internet!).

Polypogon rioplatensis fo. *robusta* Herter, Revista Sudamer. Bot. 6(5–6):140. 1940. Tipo: URUGUAY: Dep. Montevideo, in arenosis subhumidis, Carrasco, Nov 1934, *Herter 95155, 586f* (B sintipos, no vistos).

Chaetotropis imberbis var. *bonariensis* Nicora, Fl. Prov. Buenos Aires 4(2):211. 1970. Tipo: ARGENTINA: Buenos Aires, Bañado de Flores, 25 nov 1924, *Parodi 5964* (holotipo: BAA-3505 imagen internet!).

Hierbas perennes, cespitosas, erectas; cañas de 17–80 cm de alto; entrenudos de 5–9 cm de largo; nudos 2–3, lisos, estriados, castaños o marrones. Vainas de 3,5–9 cm de largo, más cortas o tan largas como los entrenudos, glabras, estriadas; lígulas membranáceas, de 1,5–3,5 mm de largo, glabras o levemente escabrosas en el dorso; láminas de 4–10 cm de largo por 2–6 mm de ancho, planas, glabras. Panículas espiciformes o subespiciformes, de 5–20 cm de largo por 0,8–2 cm de ancho; raquis glabro. Espiguillas se desprenden con un fragmento de pedicelo de 1,5–2,5 mm de largo; pedicelos de 1,8–3 mm de largo, escabrosos; glumas de 2–2,8 mm de largo (excluidas las aristas), la inferior algo mayor que la superior, 0,5–0,8 mm de ancho, escabrosas en el dorso, ápice agudo, terminado en aristas de 0,8–1,7 mm de largo; lemma de 1,2–2 mm de largo, mútica, hialina, ápice truncado, con los nervios laterales terminados en tres pequeñas aristulas de 0,2–0,4 mm de largo; callo glabro; pálea de 0,4–0,8 mm de largo, igual a la mitad de la lemma o menor que ésta, hialina; anteras de 0,5–0,6 mm de largo. Cariopsis elipsoide, de 0,9–1,5 mm de largo por 0,25–0,4 mm de ancho.

Iconografía.—Nicora (1978: 400, fig. 267a-e bajo *Chaetotropis imberbis*); Rúgolo (2012a: 169 bajo *Ch. imberbis* var. *imberbis*).

Fenología.—Florece entre noviembre y junio.

Distribución geográfica y hábitat.—Argentina, Brasil, Chile, USA y Uruguay (Soreng et al. 2003). En Chile insular se encuentra en el Archipiélago de Juan Fernández; en Chile continental se encuentra desde la Región

del Maule (Curicó) hasta la región de Los Lagos (Chiloé). Habita principalmente zonas costeras o praderas litorales no superando los 100 m de altitud, principalmente en suelos húmedos y arenosos.

Caracteres distintivos.—Glumas alargadas y estrechas terminadas en una arista de hasta 1,7 mm de largo; lemma mútica, con el ápice truncado terminado en 3 pequeñas arístulas inferiores a 0,4 mm de largo.

Observaciones.—*Polypogon rioplatensis* f. *elegans* Herter fue descrito sobre la base de dos sintipos: Herter 86494 y Herter 333d. Se eligió como lectotipo el espécimen Herter 333d depositado en US-1341869 que contiene dos plantas completas.

Especímenes adicionales examinados.—**ARGENTINA. Buenos Aires:** Lobos, Salvador María, *Burkart 10007* (SI); San Fernando, *Burkart 12969* (SI); San Fernando, Pacheco, *Boelcke 6674* (SI), Pilar, Río Lujan, *Cabrera 10309* (SI). **San Luis:** Villa Mercedes, *Burkart 10909* (SI). **Tucumán:** Leales, Chañar Rojo, 300 m, *Venturi 719* (BA). **CHILE. Región de Valparaíso:** Archipiélago de Juan Fernández, Isla Alejandro Selkirk, Quebrada de la colina hacia las Vacas, *Muñoz & Sierra 7102* (CONC); Entre Quebrada Casas y Paso Malo, 5 m, *Baeza & Peñailillo 11429* (CONC). **Región del Maule:** Curicó, 10 m, *Barros 1685* (CONC). **Región de la Araucanía:** Cautín, Puerto Saavedra, 10 m, *Montero 4368* (CONC). **Región de Los Ríos:** Valdivia, Corral, sobre rocas marítimas, 25 m, *Gunckel 491* (CONC), Cerro de la Viga, 100 m, *Gunckel 7215* (CONC); Niebla, 20 m, *Gunckel 2843* (CONC). **Región de los Lagos:** Chiloé, Isla Quilán, entre Puntas Malas y Abrigo, 20 m, *Villagrán & A. Leiva 7280* (CONC).

7. Polypogon interruptus Kunth, Nov. Gen. Sp. 1:134, t. 44. 1815 [1816]. *Alopecurus interruptus* (Kunth) Poir., Encycl. 5:495. 1817. *Polypogon littoralis* var. *interruptus* (Kunth) Kuntze, Revis. Gen. Pl. 3(3):367. 1898. TIPO: VENEZUELA: Amazonas, in sylvis opacis Orinocensibus prope Atures, Rio Cataniapo et speluncam Ataruipe, May, *Humboldt & Bonpland s.n.* (HOLOTIPO: P no visto; ISOTIPOS: B-WILLD-1558 no visto, US-82088-fragm. ex P-HBK no visto, US-82088-fragm. ex B-WILLD no visto).

Polypogon interruptus var. *breviaristatus* E. Desv., Fl. Chil. 6:298. 1854. TIPO: CHILE: Santiago, *Gay s.n.* (no localizado).

Polypogon interruptus var. *longearistata* E. Desv., Fl. Chil. 6:298. 1854. SINTIPOS: CHILE: Santiago, *Gay* (P no visto), Valparaíso, *Meyen* (P no visto), Rancagua, *Bertero 586* (P no visto) y Quillota, *Bertero 1256* (P no visto).

Polypogon microstachys Phil., Fl. Atacam. 54. 1860. TIPO: CHILE: Prope aquam Puquios dictam inter Tres Puntas at Copiapo, ca. 27°09'S, 4700 psm, *Philippi 342* [HOLOTIPO: SGO-PHIL-342: ISOTIPOS: SGO-63111!, US-fragm. ex SGO-PHIL-342 & photo).

Polypogon tarapacanus Phil., Verz. Antofagasta Pfl. 82. 1891. TIPO: CHILE: Tarapacá: ad Guaviña, oppidum Prov. Tarapacá, 13-III-1885, *F. Philippi s.n.* [HOLOTIPO: SGO-129197!; ISOTIPOS: K-308493 imagen internet!, US-fragm & foto ex SGO no visto).

Polypogon brachyatherus Phil., Anales Univ. Chile 94:8. 1896. TIPO: CHILE: prope Lebu in prov. Arauco, Jan 1877 (HOLOTIPO: SGO-31157!)

Polypogon breviaristatus Phil., Anales Univ. Chile 94:8. 1896. TIPO: CHILE: Prov. Coquimbo, Ovalle, río Torca, dic. 1890, *Geisse s.n.* (HOLOTIPO: SGO-PHIL-344!; ISOTIPOS: SGO-PHIL-63111!, SGO-71535!, SGO-72936!, US-fragm. ex SGO-PHIL-344 & foto no visto).

Polypogon purpurascens Phil., Anales Univ. Chile 94:9. 1896. TIPO: CHILE: in praedio Mercedes, prov. Santiago, Nov 1888. Philippi 345 (HOLOTIPO: SGO-PHIL-345!; ISOTIPOS: SGO-63108!, US-82086 (fragm.ex SGO-PHIL-345 & foto).

Perennes, erectas; cañas de 16–75 cm de alto; entrenudos de 4–13 cm de largo, glabros; nudos 2–3. Vainas de 3–8 cm de largo, más cortas que los entrenudos, glabras; lígulas hialinas, de 2–4 mm de largo, glabras en el dorso, denticuladas en el ápice; láminas de 4–11 cm de largo por 3–6 mm de ancho, planas, escabrosas en los márgenes. Panículas interruptas a subespeciforme, de 3–9 cm de largo, 1–2 cm de ancho, ramas laterales contraídas o algo laxas, verde amarillentas con tonos violáceos; raquis glabro. Espiguillas se desprenden con un fragmento de pedicelo de 0,3–0,7 mm de largo; pedicelos de 0,5–1,4 mm de largo, fuertemente escabrosos; glumas subiguales, de 1,5–2,3 mm de largo (excluidas las aristas), 0,4–0,6 mm de ancho, escabrosas en el dorso, ápice levemente lobulado; aristas de 1–4,8 mm de largo; lemmas de 1–2,2 mm de largo, glabras, hialinas, ápice truncado, con los nervios laterales terminados en pequeñas arístulas (0,1 mm de largo) todas de igual longitud o los nervios externos levemente más largos que los internos; arista de 0,8–2,3 mm de largo, recta u ondulada, levemente exserta, caediza, inserta en el tercio superior de la lemma (0,2–0,3 mm desde el ápice); callo glabro; pálea de 0,8–2 mm de largo, poco menor que la lemma, hialina; anteras de 0,4–0,5 mm de largo. Cariopsis elipsoide, de 1–1,8 mm de largo, 0,3–0,45 mm de ancho.

Iconografía.—Hitchcock (1951: 365, fig.512); Tovar (1993: 197, fig. 21j).

Fenología.—Florece entre agosto y febrero.

Número de cromosomas.—$2n = 28, 42$ (Tucker 1996).

Distribución geográfica y hábitat.—Argentina, Bolivia, Canadá, Chile, Colombia, Ecuador, México, Perú, USA y Venezuela (Soreng et al. 2003). En Chile se encuentra desde la Región de Arica y Parinacota, hasta la Región Metropolitana. Habita zonas costeras y zonas montañosas hasta los 3200 m de altitud.

Caracteres distintivos.—Presenta una lemma con una arista recta levemente exserta entre las glumas, panículas no espiciformes, lígula glabra y cortas aristas en las glumas.

Observaciones.—Especie muy cercana a *P. australis* de la cual se distingue por el largo menor de las aristas de las glumas; (en *P. australis* las aristas alcanzan hasta el doble de largo de la espiguilla). Sin embargo, la longitud de las aristas es variable. Los tipos de *P. breviaristatus* difieren en el largo de las aristas: SGO-71535 tiene aristas muy cortas mientras los tipos SGO-72936 y SGO-72945 tienen aristas largas (más largas que las glumas), como en *P. australis*.

La descripción original de *P. interruptus* var. *longearistata* de Desvaux (1854) hace referencia a las aristas de las glumas (1 ⅔–2 ¼ lín. = 3,6–4,86 mm) que superan el largo de éstas (1–1 ¼ lín. = 2,16–2,7 mm), las que no difieren significativamente de las aristas más cortas observadas en *P. australis* (5 mm). La var. *longearistata* fue descrita sobre la base de 4 sintipos: Santiago (*Gay*), Valparaíso (*Meyen*), Rancagua (*Bertero 586*) y Quillota (*Bertero 1256*). Los tipos no fueron ubicados por lo que no fue posible tipificar y aceptamos la sinonimia establecida por Soreng et al. (2003).

El tipo de *Polypogon interruptus* var. *breviaristatus* E. Desv. no fue ubicado; seguimos a Soreng *et al.* (2003) en la sinonimia correspondiente.

Especímenes adicionales examinados.—**CHILE. Región de Arica y Parinacota:** Arica, 2007, *Soto s.n.* (CONC-CH). Arica, Frente a Socoroma, 3300 m, *Ricardi et all 191* (CONC); Valle de Lluta, 450 m, Pfister s.n. (CONC); Valle de Lluta, 15 km después de Molinos, 450 m, *Escobar 324* (CONC), Parinacota, Putre, 2007, *Arévalo s.n.* (CONC-CH). **Región de Tarapacá:** Copiapó, 3000 m, *Werdermann s.n.* (SI); Iquique, Quebrada de Choja, 3600 m, *Argomedo 193* (CONC); Mamiña, 2700 m, *Pfister s.n.* (CONC). **Región de Antofagasta:** Antofagasta, Aguada Escondida, 2750 m, *Arancio & Squeo 10532* (CONC). **Región de Coquimbo:** Prov. Choapa, 19,1 km N de los Vilos, 15 m, *Lammers et al. 7561* (CONC). **Región de Valparaíso:** Reñaca, 10 m, *Jaffuel s.n.* (CONC). **Región Metropolitana:** Santiago, Cerro san Cristóbal, 800 m, *Jaffuel & Pirion 1864* (CONC).

8. Polypogon linearis Trin., Linnaea 10(3):301. 1836. TIPO: CHILE: bor. in campis ad Concón, 1827, *Poeppig 76* (HOLOTIPO: LE-TRIN-1569.01a; ISOTIPO: US-82051 ex W imagen internet!).

Polypogon longiflorus Nees ex Steud., Nomencl. Bot. (ed. 2) 2:378. 1841 (nomen nudum).

Polypogon longiflorus Nees ex Steud., Syn. Pl. Glumac. 1:184. 1854. TIPO: CHILE: Chile, Valparaíso, *Cuming 457* (HOLOTIPO: E-373829 pro parte, imagen internet!).

Polypogon longiflorus Nees ex Trin., Mém. Acad. Imp. Sci. Saint-Pétersbourg, Sér. 6. Sci. Math. Seconde Pt. Sci. Nat. 6.4(3–4):263. 1841. TIPO: CHILE: borealis ad campis ad Concón, Valparaíso (LECTOTIPO, designado aquí: Valparaíso, *Cuming 542*, E-373829 pro parte, imagen internet!).

Anuales, cañas de 12–35 cm de alto; entrenudos de 4–8 cm de largo, glabros; nudos 2–3. Vainas de 3–7 cm de largo, más cortas o tan largas como los entrenudos, glabras; lígulas membranaceas, de (0,5–)2–3,5 mm de largo, glabras, denticuladas en el ápice; láminas de 2,5–7 cm de largo, 2–3 mm de ancho, planas, escabrosas en los márgenes. Panículas espiciformes a subespiciformes, de 3–6(–10) cm de largo, 0,5–1,5 cm de ancho; raquis glabro o escabroso. Espiguillas caen con un trozo de pedicelo muy reducido, de 0,3–0,6 mm de largo; pedicelos de 0,8–2 mm de largo, escabrosos; glumas desiguales, la inferior de 3,2–3,8 mm de largo, la superior de 2,7–3,1 mm de largo (excluidas las aristas), subiguales en ancho (0,4–0,6 mm), escabrosas en la parte inferior del dorso; ápice lobado, menos frecuentemente algo agudo, aristado; arista de 5–7 mm de largo, en algunos casos más del doble de largo que las glumas, rectas, escabrosas; lemmas de 1–1,8 mm de largo, glabras, hialinas, ápice truncado, con 4 arístulas, las externas son levemente más largas que las internas; arista recta o algo ondulada, caediza, de 1,5–3 mm de largo, inserta en en el tercio superior de la lemma (a 0,2–0,3 mm desde el ápice), escabrosa; callo glabro; pálea de 0,8–1,5 mm de largo, poco menor que la lemma, hialina; anteras de 0,4–0,5 mm de largo. Cariopsis de 0,7–1,5 mm de largo, 0,35–0,5 mm de ancho, elíptica u ovoide; mácula embrional de 0,3 mm de largo; hilo de 0,2–0,3 mm de largo.

Iconografía.—Gay (Hist. Fís. y Polit. Chile, Bot., Atlas, Vol. 1, t. 77, 1854).

Fenología.—Florece entre los meses de octubre y febrero.

Distribución geográfica y hábitat.—Especie endémica de Chile, presente desde la Región de Coquimbo hasta la Región del Bío-Bío. Habita en zonas costeras no superando los 500 m de altitud, en suelos húmedos y arenosos.

Caracteres distintivos.—Se distingue por las glumas lineares, algo desiguales, dorsalmente escabrosas en la mitad inferior.

Observación.—*Polypogon linearis* es morfológicamente cercana a *P. monspeliensis*, de la cual se diferencia por sus espiguillas más largas (3–3,8 mm en *P. linearis*, 1,4–2,2 mm en *P. monspeliensis*). Típicamente, en *P. linearis* la arista de la gluma es apical (en *P. monspeliensis* inserta en la incisión del ápice bilobado).

Especímenes adicionales examinados.—**CHILE. Región de Coquimbo:** Choapa, Huentelauquén, 60 m, *Jiles 2841* (CONC). **Región de Valparaíso:** Casablanca, 250 m, *Garaventa 5288* (CONC); Quintero, Los Juanes, 20 m, *Navas s.n.* (CONC); Campiche, 20 m, *Gunckel 35725* (CONC); Quillota, Limache, Lliu-Lliu, 255 m, *Garaventa 2254* (CONC). **Región Metropolitana:** Santiago, Chacabuco, Batuco, 480 m, *Gunckel 26835* (CONC); Batuco, 480 m, *Montero 563* (CONC); Batuco, 480 m, *Gunckel 26719* (CONC); Batuco, 480 m, *Looser 3631* (CONC); Batuco, 480 m, *Gunckel 26739* (CONC); Peñaflor, 450 m, *Montero 193* (CONC); Quebrada la plata, 740 m, *Schlegel 3198* (CONC). **Región de O'Higgins:** Cachapoal, San Fernando, cerro Echaurrina, 350 m, *Montero 1353* (CONC). **Región del Maule:** Cauquenes, 5,8 km S del desvio a Sauzal, 125 m, *Bliss & Lusk 808* (CONC). **Región del Biobío:** Concepción, Hualpén, 20 m, *Barros 159* (CONC); Ñuble, entre San Nicolás y Ninhue, Coipín, *Finot 2304* (CONC-CH).

9. Polypogon magellanicus (Lam.) Finot, comb. nov. *Agrostis magellanica* Lam., Tabl. Encycl. 1:160. 1791. *Vilfa magellanica* (Lam.) P. Beauv., Ess. Agrostogr. 16, 148, 181. 1812. TIPO: E. Magellania, *Commerson s.n.* (HOLOTIPO: P imagen internet!; ISOTIPOS: BAA fragm. & foto no visto, CONC fragm.!, G, LE-TRIN-1620.01 no visto, US 75358 fragm. no visto).

Agrostis antartica Hook. f., Fl. Antarct. 2:374, t. 132. 1846. *Agrostis magellanica* var. *antarctica* (Hook. f.) Franch., Miss. Sci. Cape Horn, Bot. 5:381. 1889. *Agrostis magellanica* var. *antarctica* (Hook. f.) Pilg., Repert. Spec. Nov. Regni Veg. 12:304. 1913, non Franch. 1889. TIPO: Hab. South Chile and Fuegia, from the Chonos Archipielago to Cape Horn, the Falkland Islands and Kerguelen's Land, very important, *J.D. Hooker s.n.* (LECTOTIPO: K designado por Rúgolo & Molina en Anton, A. & F. Zuloafa, Fl. Argentina 3(2): 144, 2012, no visto; ISOLECTOTIPOS: BAA-4134 ex K imagen internet!; BAA-4135 ex K imagen internet!; BAA-4136 ex K imagen internet!).

Agrostis cognata Steud., Syn. Pl. Glumac. 1:421. 1854. *Agrostis magellanica* var. *cognata* (Steud.) Macloskie & Dusén, Rep. Princeton Univ. Exp. Patagonica, Botany, Suppl. 8(3):40. 1914 [1915]. TIPO: CHILE: Prope Sandy Point, Magellan, *Lechler 1223* (HOLOTIPO: K no visto; ISOTIPOS. BAA fragm. ex P, imagen internet!, P-740568 imagen internet!, P-740569 imagen internet!, P-740570 imagen internet!, S-05-10091 imagen internet!, SGO 68435!).

Agrostis chonotica Phil., Linnaea 29(1):87. 1858. TIPO: CHILE: in litore archipelagi Chonos dicti, *Fonk*. 52 (HOLOTIPO: SGO-PHIL 143!; ISOTIPO: US-556313 framg, ex SGO imagen internet!).

Agrostis araucana Phil., Anales Univ. Chile 94:14. 1896. TIPO: CHILE: Araucania ad lacum Guaieltué unde nascitur fluvium Biobio, Feb 1887, *Rahmer s.n.* (HOLOTIPO: SGO-PHIL-181!; ISOTIPOS: BAA-4137 fragm. ex SGO imagen internet!, BAA-4138 fragm. ex K imagen internet!, BM imagen internet!, SGO-37479!, SGO-45505!).

Agrostis macrathera Phil., Anales Univ. Chile 94:10. 1896. TIPO: CHILE: In valle fluminis Palena, 43°45' lat. aust., *A. Hirth s.n.* (HOLOTIPO: SGO-PHIL-153; ISOTIPOS: BAA-4221 imagen internet!, US-556330 fragm. & foto ex SGO imagen internet!).

Agrostis multiculmis Hook. f., Fl. Antarct. 1:95. 1845. HOLOTIPO: NUEVA ZELANDA: on sloping banks about 500 ft above the sea on the west side of Campbell's Island, porstate, Dec 1840, *J.D. Hooker 1628* (HOLOTIPO: K no visto; ISOTIPO: BM imagen internet!).

Agrostis rinihuensis Phil., Anales Univ. Chile 94:14. 1896. TIPO: CHILE: in valle fluminis Riñihue en Patagonia occidentali, *L.F. Delfin s.n.*(HOLOTIPO: SGP-PHIL 166; ISOTIPOS: SGO 63133, US 556340 fragm. ex SGO-PHIL 166).

Perennes, rizomatosas, de (11–)25–90 cm de alto; entrenudos de 8–17 cm de largo; nudos 2–3, glabros. Vainas de (3–)5–16 cm de largo, más cortas que los entrenudos, glabras; lígulas de 2–6 mm de largo, hialinas, subtriangulares, agudas en el ápice, lisas o escabrosas en el dorso, decurrentes con la vaina, a veces laciniadas; láminas planas o conduplicadas, de 5–15 cm de largo por 1–6 mm de ancho, glabras o escabrosas en la cara adaxial y márgenes. Panículas laxas o subespiciformes, de 5–16 cm de largo, 1–6 cm de ancho, verdes, doradas o purpúreas con ramas laterales contraídas o laxas; raquis escabroso-hirsuto. Espiguillas se desprenden con un fragmento de pedicelo de 1–4 mm de largo; pedicelos de 1–6 mm de largo, escabroso-hirsutos; glumas subiguales de 3–5,5 mm de largo por 0,4–0,8 mm de ancho, verdes con tintes purpúreos, 1-nervias, con la quilla escabrosa, lisas en el dorso, múticas o mucronadas, mucrón de 0,1–0,6 mm de largo; lemmas hialinas, de 1,5–2,2 mm de largo, lisas o escabrosas en el dorso, con el ápice truncado o 3-dentado, 5-nervia, los nervios apenas extendidos más allá del ápice; arista de 2–6 mm de largo, inserta en la mitad o en el tercio superior del dorso de la lemma, geniculada y retorcida, escabrosa, exserta; callo glabro o con dos mechones de pelos escasos a cada lado, pelos de 0,2–0,4 mm de largo; pálea de 0,4–0,8 mm de largo o reducida; lodículas de 0,4–0,5 mm de largo, agudas o bilobuladas; anteras de 0,5–0,7 mm de largo. Cariopsis elipsoidal u ovoide, castaña, de 1,1–1,5 mm de largo, 0,4–0,6 mm de ancho; mácula embrional de 0,3–0,5 mm de largo; hilo de 0,2–0,5 mm de largo.

Iconografía.—Rúgolo & Molina (1977a: 143, fig. 12f-j bajo *Agrostis magellanica*)

Fenología.—Florece desde diciembre a febrero.

Distribución geográfica y hábitat.—Argentina y Chile (Soreng et al. 2003). En Chile se encuentra desde la Región del Bío-Bío hasta la región de Magallanes y Antártica Chilena, entre 10 y 1200 m de altitud. Crecen en suelos principalmente húmedos, a veces arenosos.

Caracteres distintivos.—Se caracteriza por sus panículas laxas amplias y antecios con arista larga (3–5,5 mm), inserta en la zona media de la lemma, geniculada y retorcida.

Especímenes adicionales examinados.—**ARGENTINA. Chubut:** Tehuelches, Lago la Pasa, *Nicora 10079* (SI), Lago Vintter, *Nicora 9253* (SI). **Neuquén:** Huilliches, Lago Epulafquén, *Dawson & Schwabe 2676* (CONC); Los Lagos, Pto. Manzano, lago Nahuel Huapi, Villa La Angostura, *Rúgolo 1249* (SI). **Río Negro:** P.N. Nahuel Huapi, Lago Roca, *Boelcke & Correa 5845* (SI). **Tierra del Fuego:** Isla de los Estados, Puerto Vancouver, *Dudley et al. 1005* (SI). **CHILE. Región de Los Ríos:** Valdivia, Trumao, 65 m, *Hollermayer 1265*a (CONC). **Región de Los Lagos:** Osorno, P.N. Puyehue, Laguna Las Mellizas, N of the highway, ca. 7 km W of Paso Cardenal Antonio Samore to Argentina, E of Osorno ca. 90 km, 1035 m, *Soreng & Soreng 7237* (CONC); Chiloé, Piruquina, Changao Grande, barbecho, 160 m, *Junge 241* (CONC); Piruquina, 25 m, *Junge s.n.* (CONC); Isla Nayahué, costa W, 10 m, *Villagrán & Aguila 6672* (CONC); Lago Río Negro, 100 m, *Villagrán et al. 6954* (CONC); Isla Grande de Chiloé, Río Puntra, Vega Caucamán, 25 m, *Villagrán 3598* (CONC); trayecto de Lago Río Negro a Caleta Gonzalo, 200 m, *Villagrán et al. 7004* (CONC); Llanquihue, Cayutué, 180 m, 1935, *Edding & Ross s.n.* (CONC). **Región de Aysén:** Islas Guaytecas, Melinka, 100 m, *Ricardi & Marticorena 4081a* (CONC); Lago Yulton, Ensenada Caipillán, 100 m, *García 3958* (CONC); Lago Yulton, lecho del Río Macá, 500 m, *García 3966* (CONC); Fiordo Aysén, NW desembocadura del Río Cuervo, 5 m, *García 3914* (CONC); Río Coyhaique, 500 m, *Navas s.n.* (CONC); Lago Caro, playa cascada orilla sur, 215 m, *García 4085* (CONC); Río Blanco, 130 m, *García 4042* (CONC); Río Exploradores, Estancia Santa Teresa-Bahía Exploradores, 40 m, *Seki 344* (CONC); General Carrera, Ventisquero Soler, on the moraines, 500 m, *Seki 532* (CONC); San Rafael, cercanías cerro al E del hotel, 100 m, *Schlegel 2145* (CONC); San Rafael, Río Guala, 10 m, *Schlegel 2029* (CONC); Laguna San Rafael, lado oriente, sector del antiguo hotel, 100 m, *Teillier & Márquez 4335, 4336* (CONC); P.N. Laguna San Rafael, sector hotel, entre la llanura areno-ripiosa y la playa, *Pisano 6202* (CONC); Laguna San Rafael, ribera Este, sector del antiguo hotel, 100 m, *Teillier & Márquez 4412* (CONC); Lago San Rafael, Rada Quesahué, orilla de canal, 100 m, *Schlegel* 2025, 2034 (CONC). **Región de Magallanes y Antártica Chilena:** Última Esperanza, P.N. Torres del Paine, 3 km NW de Refugio Pingo, 100 m, *Elvebakk 280* (CONC); Puesto Weber, Estancia Payne, *Pisano 4296* (CONC); Puerto Bellavista, P.N. Monte Balmaceda, afloramientos rocosos entre 50–120 m del frente del Glaciar Balmaceda, *Pisano et al.* 8476 (CONC); morrena cercana al lago proglacial, *Pisano et al. 8379, 8485, 8461*, 8506 (CONC); Fiordo Peel, Río Murtillar, *Pisano 6032* (CONC); Península Muñoz Gamero, entrada al lago, *Dollenz 15* (CONC); Magallanes, Bahía del Indio, Lote San Isidro, Río Yumbel, 20 m, *Pisano 3946, 3952* (CONC); Isla Recalada, costa norte, *Cárdenas 47* (CONC); Bahía Furia, Isla Furia, en turba graminosa, *Cárdenas 63, 67* (CONC); Cabo Froward, Bahía Rosa, *Pisano 6582* (CONC); Río Santa María, 5 m, *Pisano 3511* (CONC); Río Santa María, *Pisano 2527* (CONC); Laguna El Parrillar, *Pisano 5735* (CONC); Fiordo Nevado, Isla Santa Inés, Bahía Havergal, *Pisano & Henríquez 6604, 6620, 6690* (CONC); Bahía Havergal, *Henríquez & Palma 21* (CONC); Punta Arenas, refugio Club Andino, 460 m, *Pisano 2164, 2166* (CONC); Punta Arenas, cerros cancha de sky, 120 m, *Pfister & Ricardi s.n.* (CONC); Isla Englefield, Seno Otway, *Pisano & Cárdenas 4877* (CONC); Tierra del Fuego, camino a Puerto Arturo, cabo Nose, bosque mixto de canelo, *Pisano et al. 7737* (CONC); Aserradero Río Bueno, *Pisano 2465* (CONC); Sector Río Cóndor, Forestal Trillium, bosque costero camino a Puerto Arturo, *Pisano et al. 7971* (CONC); turbal camino norte, *Pisano et al. 7893* (CONC); turbal y bosque en borde de laguna, *Pisano et al. 7903, 7914* (CONC); Fiordo Parry, P.N. Alberto de Agostini, Glaciar Nueva Zelandia, *Pisano et al. 8726, 8790* (CONC); Glaciar Reina Isabel II, *Pisano et al. 3026, 8825, 8862* (CONC); Sector Timaukel, Lote 2, Forestal Trillium, bosque de coigüe, *Pisano et al 7678, 7785, 7834, 7835*, (CONC); Lote 12, Forestal Trillium, bosque coigüe-lenga intervenido, *Pisano et al. 7657, 7612* (CONC); Sector Vicuña, Forestal Trillium, Lote 12A, *Pisano & Henríquez 6947* (CONC); Valle del Río Cuchara, *Pisano et al. 7593* (CONC); Puerto Edwards, 20 m, *Parra 251* (CONC); Antártica Chilena, fiordo Contralmirante Martínez, brazo sur-este, en pastizal costero, *Henríquez & Palma 50* (CONC); Fiordo Contralmirante Martínez, brazo S-E, en pastizal costero y rocas, *Henríquez & Palma 57* (CONC); Isla Bayly, Bahía Beaufort, en dunas de conchillas, *Dollenz 849* (CONC); Isla Wollaston, Caleta Lientur, a orillas del mar, *Dollenz 810* (CONC 137967); Caleta Awaiakirrh, Isla Hoste, Seno Ponsomby, en itsmo, *Pisano 5480* (CONC); Isla Grevi, Bahía Gretton, Rada Norte, *Pisano 5355* (CONC).

10. Polypogon monspeliensis (L.) Desf., Fl. Atlant. 1:67. 1798. *Alopecurus monspeliensis* L., Sp. Pl. 1:61. 1753. *Alopecurus aristatus* var *monspeliensis* (L.) Huds., Fl. Angl. 2:28. 1778. *Agrostis alopecuroides* Lam., Tabl. Encycl. 1:60. 1791. *Phleum crinitum* Schreb., Beschr. Gras. 1:151. 1769. *Agrostis crinita* (Schred.) Moench, Methodus 178. 1794. *Phleum monospliense* (L.) Koeler, Descr. Gram. 57. 1802. *Polypogon crinitus* (Schreb.) Nutt., Gen. N. Amer. Pl. 1:50. 1818. *Santia monspeliensis* (L.) Parl., Fl. Palerm. 1:73. 1845. Tipo: EUROPA. *Anon*. Lectotipo: herb. LINN-82.6, designado por Hubbard, Fl. Trop. East Afr. Gramineae 1:100. 1970; designación restringida a carpeta (LINN) por Scholz en Cafferty *et al*., Taxon 49(2):245. 2000 (isolectotipo: BAA 4131-imagen internet!).

Cynosurus paniceus L., Sp. Pl. 1:73. 1753; *Alopecurus paniceus* (L.) L., Sp. Pl. 1(ed. 2):90. 1762. Lectotipo: LINN-82.8, designado por Scholz, in Cafferty et al., Taxon 50(2):250 2000 (LINN-82-8, imagen internet!).

Phalaris crinita Forssk., Fl. Aegypt.-Arab. 19. 1775. Tipo: TURKEY: Izmir, *Forsskal 80* (C, no visto).

Phalaris cristata Forssk., Fl. Aegypt.-Arab. 17. 1775. Tipo: EGYPT: circa Káhiran frequens, *Forsskal 68, Forsskal 69* (Sintipos: C (*Forsskal 69* imagen internet!)).

Phalaris aristata Gouan ex P. Beauv., Ess. Agrostogr. 172. 1812 (nom. illeg., non *Phalaris aristata* Schousb. ex Willd., Ges. Natturf. Freunde Berlin Neue Schriften 3:413. 1801).

Polypogon flavescens J. Presl, Reliq Haenk. 1:234. 1830. TIPO: PERÚHabitat in Peruvia, *Haenke s.n.* [HOLOTIPO: PR, no visto; ISOTIPO: US-fragm. ex PR, no visto).

Polypogon monspeliensis f. *argentinus* Hack., Anales Mus. Nac. Buenos Aires 11:108. 1904. TIPO: ARGENTINA: *Stuckert hb. 12266, 12286b* (SINTIPO: W, no visto; ISOSINTIPO: SI-62369 imagen internet!; US-fragm. ex W, no visto).

Polypogon monspeliensis f. *nana* Stuck., Anales Mus. Nac. Buenos Aires 21:95. 1911. TIPO: ARGENTINA: Río IV, *Stuckert hb. 16833* (no localizado).

Anuales, erectas o decumbentes; cañas de (11–)35–75 cm de alto; entrenudos de 5–15 cm de largo, glabros, estriados; nudos 2–4, glabros. Vainas de 4–11 cm de largo, más cortas tan largas como los entrenudos, glabras o escabrosas; lígulas hialinas, opacas, de 1–5 mm de largo, glabras o algo escabrosas en el dorso, denticuladas en el ápice; láminas de (3–)8–14 cm de largo, 2–6 mm de ancho, planas, escabrosas en ambas caras y márgenes, ápice agudo. Panículas espiciformes, amarillentas o verde pálido, de 2–8 cm de largo, 1–2,2 cm de ancho; raquis escabroso. Espiguillas se desprenden con un fragmento del pedicelo de 0,1–0,2 mm de largo; pedicelos de 0,25–0,6 mm de largo, fuertemente escabrosos; glumas aristadas, subiguales, de 1,4–2,2 mm de largo (excluidas las aristas), 0,4–0,5 mm de ancho, escabrosas en el dorso, con el ápice bilobulado; aristas de 2–5 mm de largo, más largas que las glumas, rectas u onduladas, escabrosas; lemmas de 0,8–1,3 mm de largo, glabras, hialinas, brillantes, ápice truncado, 4-dentado; arista recta, de 0,8–2 mm de largo, inserta en el ápice o en el tercio superior de la lemma (a 0,2–0,3 mm del ápice), exserta o no, escabrosa; callo glabro; pálea de 0,7–1,1 mm de largo, poco menor que la lemma, hialina; anteras de 0,3–0,45 mm de largo. Cariopsis de 0,4–1 mm de largo, 0,25–0,35 mm de ancho, ovalado o elíptico, muy adherido a las glumas; mácula embrional de 0,2–0,4 mm de largo; hilo de 0,2–0,3 mm de largo.

Iconografía.—Doell & Hackel (1895: Tab. XII, fig. I); Hitchcock (1951: 364, fig. 510); Nicora (1978: 396, fig. 263a-e); Rúgolo et al. (2008: 29, fig. 7a-c).

Número cromosómico.—$2n = 14, 28$ (Tucker 1996).

Fenología.—Florece entre noviembre y febrero.

Distribución geográfica y hábitat.—Especie de origen eurasiático, introducida en América donde se extiende desde Canadá hasta Chile y Argentina. Se encuentra en Norteamérica (Canadá, Estados Unidos, México), Centroamérica (Costa Rica, Guatemala) y Sudamérica (Argentina, Bolivia, Brasil, Chile, Ecuador, Paraguay, Perú, Uruguay) (Hitchcock 1927; Soreng et al. 2003; Rúgolo et al. 2008). En Chile se encuentra desde la región de Arica y Parinacota, hasta la región de Los Lagos, desde los 30 m de altitud en las zonas costeras hasta los 3000 m de altitud en las zonas montañosas. Crece sobre lechos rocosos de embalses, orillas de camino, zonas ribereñas junto a *Cortaderia*, *Tessaria absinthioides* y *Baccharis*, en chacras y orillas del ríos (*Villagrán 9617*), en suelo arenoso (*Gunckel 30442*), suelo salobre (*Gunckel 18719*) y como maleza en cultivo de arroz (*Rodríguez & Baeza 2345*).

Caracteres distintivos.—Se caracteriza la panícula espiciforme, densa, con espiguillas cortamente pediceladas, las glumas bilobuladas, provistas de largas aristas que nacen desde la incisión del ápice bífido, los lóbulos del ápice generalmente ciliados.

Observación.—Especie afín a *P. maritimus* con la cual se puede confundir. Se distingue por las glumas levemente bilobadas, los lóbulos 1/8–1/6 del largo de las glumas; en *P. maritimus* las glumas son profundamente bilobadas (los lóbulos alcanzan 1/4–1/3 del largo de las glumas) y por la arista de la lemma (presente en *P. monspeliensis*, ausente en *P. maritimus*). Los ejemplares de *P. maritimus* citados para Chile (*Parra & Rodríguez 77; Olea 79*) corresponden a *P. monspeliensis*, por lo que se descarta la presencia de *P. maritimus* en Chile. El tipo de *P. monspeliensis* f. *nana* no fue localizado; en la sinonimia seguimos a Rúgolo (2012b).

Especímenes adicionales examinados.—**ARGENTINA. Buenos Aires:** Magdalena, *Faggi & Cagnoni s.n.* (BA). **CHILE. Región de Arica y Parinacota:** valle de Azapa, al interior de Arica, 50 m, *Gaaventa 5478* (CONC). **Región de Tarapacá:** Iquique, Mamiña, 2700 m, *Richter s.n.* (CONC). **Región de Antofagasta:** Antofagasta, 16 km al N de Antofagasta, camino a Tocopilla, 100 m, *Matthei 496* (CONC); El Loa, Chiuchiu, 2560 m, *Pfister s.n.* (CONC); Río Grande, 3250 m, *Villagrán et al. 9617* (CONC); Catarpe, curso superior del río San Pedro, 2640 m, *Rodríguez 3240* (CONC); curso superior de río San Pedro, El Tranque, 2640 m,. *Rodríguez & Ruiz 3753* (CONC); San Pedro de Atacama, alre-

dedores de la plaza y del cementerio, 2610 m, *Baeza et al. 378* (CONC); ruinas al NW de San Pedro de Atacama, 2600 m, *Rodríguez & Rivera 28* (CONC); Tocopilla, Cobija, 15 m, 1950, *A. Pfister s.n.* (CONC); Quebrada de Mamilla, 900 m, *Ricardi et al. 1068* (CONC). **Región de Atacama:** Copiapó, camino de Nantoco a La Guardia km 75, 2327 m, *Peterson et al. 15451* (CONC); Quebrada Santa Rosa, 3300 m, *Arancio 629* (CONC); Laguna del Negro Francisco, 4150 m, *Arancio 670* (CONC); Huasco, Freirina, 90 m, 1950, *A. Pfister s.n.* (CONC); Quebrada de Paipote, Vega Redonda, 2000 m, *Marticorena et al. 498* (CONC). **Región de Coquimbo:** Choapa, 1,4 km west of Panamerican Hwy, on road to Pichidangui, 10 m, *Lammers et al. 7695* (CONC); Cavilolén, 515 m, *Jiles 4040* (CONC); Illapel, cuesta El Espino, 1200 m, *Jiles 1635* (CONC); Limarí, 6 km S de Corral, 600 m, *Lammers et al. 7579* (CONC); Termas de Soco, 100 m, *Ricardi 5562* (CONC); Zorrilla, 350 m, *Jiles 420* (CONC). Ovalle, Tongoy, quebrada Salinas, 110 m, *Jiles 1657* (CONC). **Región de Valparaíso:** San Antonio, entre Mirasol y Algarrobo, 45 m, *Matthei & Quezada 322* (CONC); Cartagena, 60 m, *Schlegel 309* (CONC); Quillota, Túnel de la Calavera, 320 m, *Gunckel 46208* (CONC); Limache, estero de Maitenes, 120 m, *Garaventa 2250* (CONC); Quintero, 20 m, *Gunckel 24386, 28055, 30442* (CONC); Ritoque, 10 m, *Gunckel 46896* (CONC); Valparaíso, fundo El Cuadro, cerca de Casablanca, 400 m, *Looser 4419* (CONC); Petorca, Catapilco, 6,2 km W de la carretera Panamericana entre Catapilco y La Laguna, 125 m, *Bliss 683, 706* (CONC); Marga-Marga, 150 m, *Jaffuel & Pirión 1839* (CONC); Reñaca, cerca de Viña del Mar, 10 m, *Garaventa 3281* (CONC); Archipiélago Juan Fernández, Isla Alejandro Selkirk, Quebrada Vacas, 40 m, *Ruiz & Lammers 8042* (CONC); cementerio, al N de quebrada Casas, 20 m, *Stuessy & Lammers 8324-a* (CONC pro-parte, mezclado con *P. imberbis*); Isla Robinson Crusoe, San Juan Bautista, *Rondanelli & Humaña 11518* (CONC); Isla Robinson Crusoe, Quebrada Puerto Francés, 100 m, *López 11603* (CONC); San Antonio, Llolleo, 10 m, *Mahu 166* (CONC); El Tabo, quebrada Cordova a 20 km de Cartagena, 80 m, *Levi 1047* (CONC). **Región Metropolitana:** Santiago, Chacabuco, Batuco, 480 m, *Gunckel 18247, 18719, 26721, 26722, 43887* (CONC); Batuco, 480 m, *Levi 2210* (CONC); Batuco, 480 m, *Montero 2118* (CONC); laguna Batuco, 480 m, *Looser 2038* (CONC); Batuco, fuera de las pozas, 480 m, *Looser 3437, 3632, 3634* (CONC); Batuco, tranque Ortega, *Schlegel 3961* (CONC); Batuco, 480 m, *Jaffuel 1869* (CONC); Colina, 900 m, *Schlegel 3952* (CONC); Marruecos, 430 m., *Gunckel 28749* (CONC); Polpaico, El Taco, 522 m, *Saa 41182* (CONC); Melipilla, 175 m, *Gunckel s.n.* (CONC); El Tagueral, cerca de Lampa, 470 m, *Araya 26* (CONC); Santa Luisa, cerca de Quilicura, 450 m, *Matthei & Quezada 603* (CONC); San José de Maipo, Cajón Morales, vegas del Ruhillas, 2100 m, *Teillier & Márquez 5181* (CONC); Santiago, cerro San Cristóbal, 800 m, *Gunckel 18267* (CONC); Santiago, cuesta La Dormida, 1160 m, *Gunckel 29954* (CONC); Lampa, Taqueral, 1985, *Araya s.n.* (CONC-CH). **Región de O'Higgins:** Cardenal Caro, río Rapel, 10 m, 1961, *Palacios s.n.* (CONC); Cardenal Caro, Alcones, 150 m, *Bliss 735* (CONC); Cachapoal, Termas de Cauquenes, *Pfister s.n.* (CONC). **Región del Maule:** Curicó, Vichuquén, 50 m, *Barros 1622* (CONC); Curicó, 8 km al N de R.N. Laguna Torca, quebrada y cerros frente a la playa, 20 m, *Finot & Leppe 121* (CONC); Linares, a lo largo del río Achibueno, desde junta estero Las Animas a junta estero Riecillo, *Ruiz & López 1207, 1218, 1271* (CONC); Talca, predio Venecia, 1 km al sur de Talca en cultivo de arroz, en el pretil, *Rodríguez & Baeza 2345* (CONC). **Región del Bío-Bío:** Concepción, 10 m, *Barros 1833* (CONC); Barrio Universitario, 50 m, *Pfister 342* (CONC); La Toma, 100 m, 1943, *Pfister s.n.* (CONC); Talcahuano, Isla Rocuant, 5 m, *Rodríguez et al. 4042* (CONC); vegas de San Vicente, 15 m, *Junge s.n.* (CONC); Ñuble, camino de Concepción a Bulnes, fundo Chillán, 136 m, *Olea 79* (CONC); camino entre Bulnes y Chillán, sector El Espinal, 80 m, *Baeza 1719* (CONC); entre Chillán y Bulnes, Larqui, *Finot 2053* (CONC-CH); Bulnes, puente El Roble, 64 m, *Parra & Rodríguez 77* (CONC), Chillán, Estación Experimental INIA-Quilamapu, cultivo de arroz, *Finot 11* (CONC-CH); Nueva Aldea, riberas del río Itata, 1983, *Medina & Padilla s.n.* (CONC-CH); Ñuble, Ninhue, laguna, *Finot & Solís 2265* (CONC-CH).; Ninhue, Coipín, *Finot 2299* (CONC-CH). **Región de la Araucanía:** Cautín, Temuco, cerro Ñielol, 160 m, *Gunckel 12581* (CONC); Curarrehue, a orillas de un estero, 900 m, 1946, *Cañulaf s.n.* (CONC). **Región de Los Ríos:** Valdivia, terrenos inundados periódicamente por el río Valdivia, 8 m, *Gunckel 37582* (CONC). **Región de Los Lagos:** Chiloé, campamento El Volcán, 3 km al SW de Lago Blanco, 100 m, *Villagrán et al. 7055-B* (CONC). **USA. Washington:** Keyport, Kitsap, on the sandy back beach, *Eyerdam s.n* (BA).

11. Polypogon viridis (Gouan) Breistr., Bull. Soc. Bot. France 110 (89 Sess. Extraord.):56. 1966. *Agrostis viridis* Gouan, Hortus Monsp. 546. 1762. TIPO: FRANCE: (HOLOTIPO: P no visto).

Agrostis verticillata Vill., Prosp. Hist. Pl. Dauphiné 16. 1779 non *Agrostis verticillata* Lam (1783). *Agrostis alba* var. *verticillata* (Vill.) Pers., Syn. Pl. 1:76. 1805. *Agrostis villarsii* Poir., Encycl. 1:251. 1810. *Vilfa verticillata* (Vill.) P. Beauv., Ess. Agrostogr. 16, 148, 182. 1812. *Agrostis stolonifera* var. *verticillata* (Vill.) St.- Amans, Fl. Agen. 28. 1821. *Agrestis verticillata* (Vill.) Bubani, Fl. Pyren. 4:282. 1901. *Nowodworskya verticillata* (Vill.) Nevski, Trudy Bot. Inst. Akad. Nauk S.S.S.R, Ser. 1, Fl. Sist. Vyssh. Rast. 3:143. 1937. TIPO: FRANCE: (HOLOTIPO: P no visto).

Agrostis decumbens Muhl. ex Eliiott, Sketch Bot. S. Carolina 1:136. 1816 (nomen nudum). TIPO: U.S.A. SOUTH CAROLINA: Charleston (no localizado).

Agrostis alba var. *densiflora* Guss., Suppl. Fl. Sic. Prodr. 1:15. 1832. *Agrostis stolonifera* var. *densiflora* (Guss.) Chiov., Malpighia 35:67. 1939. TIPO: ITALY: Sicily (no localizado).

Agrostis condensata Willd. ex Steud., Nomencl. Bot. 1:40. 1840. TIPO: FRANCE: Nom. inval., citado como sinónimo de *Agrostis verticillata* Vill.

Agrostis aquatica Buckley, Proc. Acad. Nat. Sci. Philadelphia 14:90. 1862, non *Agrostis aquatica* Pourr. (1783). TIPO: U.S.A. TEXAS. San Saba Co.: San Saba, on small floating islands in the mill pond or large spring (no localizado).

Agrostis kauaiensis Hillebr., Fl. Hawaian Isl. 516. 1888. TIPO: U.S.A. HAWAII: Waimea, Kauai, 2000–3000 ft, *Mann & Brigham 273* (ISOTIPO: MO-2872433 imagen internet!).

Phalaris semiverticillata Forssk., Fl. Aegypt.-Arab. 17. 1775. *Agrostis semiverticillata* (Forssk.) C. Chr., Dansk Bot. Ark. 4(3):12. 1922. *Nowodworskya semiverticillata* (Forssk.) Nevski, Trudy Bot. Inst. Akad. Nauk S.S.S.R, Ser. 1, Fl. Sist. Vyssh. Rast. 4:339. 1937. *Polypo-*

gon semiverticillatus (Forssk.) Hyl., Uppsala Univ. Arsskr. 7:74. 1945. *Polypogon subverticillatus* (Forssk.) Hyl., Uppsala Univ. Arsskr. 7:74. 1945. *Polypogon semiverticillatus* (Forssk.) Hoover, Leafl. W. Bot. 5(8):138. 1948. TIPO: EGYPT:Rosettae et Kahirae frequens, *Forsskal s.n.* (SINTIPOS: C imagen internet!).

Polypogon littoralis var. *muticus* Hook. f., Fl. Brit. India 7:246. 1896. TIPO: INDIA: Kunawur, *Thompson* s.n. (no localizado).

Perennes, a veces estoloníferas, geniculadas en la base, enraizantes en los nudos; cañas de 20–90 cm de alto; entrenudos de 5–12 cm de largo, glabros, estriados; nudos 2–3, glabros. Vainas de 3–7 cm de largo, algo más cortas que los entrenudos, glabras; lígulas membranáceas, de 1–5 mm de largo, glabras o escabrosas en el dorso, denticuladas en el ápice; láminas de 2–13 cm de largo, 2–6 mm de ancho, planas, glabras a escabérulas en ambas caras, angostadas en la base, agudas en el ápice, nervio medio inconspicuo. Panícula contraída o laxa, verde pálido o con tintes purpúreos, de 1,5–13 cm de largo, 0,5–3 cm de ancho, generalmente interrupta, densiflora, con ramas laterales contraídas; raquis glabro o escabroso. Espiguillas de 1,5–2 mm de largo, se desprenden con un fragmento de pedicelo de 0,2–0,6 mm de largo; pedicelos de 0,2–1 mm de largo, fuertemente escabrosos; glumas subiguales, de 1,5–2 mm de largo, 0,2–0,4 mm de ancho, escabrosas en el dorso y en la quilla, ápice agudo o levemente lobado, múticas o rara vez provistas de un pequeño mucrón de hasta 0,3 mm de largo; lemma de 0,8–1,5 mm de largo, hialina, brillante, mútica, el ápice 4-dentado; callo glabro; pálea de 0,7–1,4 mm de largo, casi tan larga como lemma, hialina; anteras de 0,4–0,5 mm de largo. Cariopsis de 0,6–0,9 mm de largo, 0,3–0,4 mm de ancho, ovoide a fusiforme, débilmente estriada.

Iconografía.—Hitchcock (1951: 338 fig. 463 bajo *Agrostis semiverticillata*); Nicora (1978: 396, fig. 264 bajo *Polypogon semiverticillatus*).

Número cromosómico.—$2n = 14, 28, 42$ (Tucker 1996).

Fenología.—Florece entre septiembre y abril.

Distribución geográfica y hábitat.—Especie cosmopolita. En Chile se encuentra desde la Región de Arica y Parinacota (ca. 18°S), hasta la región de La Araucanía (ca. 38°S), desde los 5 m hasta los 2500 m de altitud, principalmente en suelos húmedos.

Caracteres distintivos.—Glumas no aristadas; panículas más o menos laxas, con ramas verticiladas.

Observaciones.—Los tipos de *Agrostis decumbens*, *A. alba* var. *densiflora* y *A. aquatica* no fueron localizados; en la sinonimia seguimos a Soreng et al. (2003).

Especímenes adicionales examinados.—**CHILE. Región de Arica y Parinacota:** Arica, 20 m, *Jaffuel 1094* (CONC); valle de Azapa, 220 m, *Escobar 316* (CONC). **Región de Tarapacá:** Iquique, Alto Hospicio, 250 m, *Ricardi 3587* (CONC). **Región de Antofagasta:** 16 km al norte de Antofagasta, camino a Tocopilla, 100 m, *Matthei 500* (CONC); Antofagasta, Quebrada de la Negra, 1250 m, *Varas s.n.* (CONC); Taltal, La Quinta, 225 m, *Quezada & Ruiz 413* (CONC). **Región de Coquimbo:** Limarí, Cabrería, 900 m, *Jiles 1142* (CONC); cordillera de Combarbalá, Hacienda Ramadilla, 3000 m, *Jiles 6162* (CONC); río Limarí, 190 m, *Jiles 1089, 1105* (CONC). **Región de Valparaíso:** Valparaíso, camino costero Reñaca a Concón, 5 m, *Poblete 128* (CONC); Horcón, 20 m, *Gunckel 69624* (CONC); Pajonal, 100 m, *Behn s.n.* (CONC); Quintero, Campiche, 20 m, *Gunckel 35726* (CONC); Quintero, 20 m, *Gunckel 48072* (CONC); Los Juanes, 20 m, *Gunckel 39329* (CONC); Playa de las Conchitas, 20 m, *Gunckel 39998* (CONC); Ritoque, 20 m, *Gunckel 41019* (CONC); Loncura, 20 m, *Barrientos 1544* (CONC); Los Andes, entre río Blanco y río Aconcagua, 1250 m, *Hutchison 128* (SGO); Quillota, Limache, en Jardín, 90 m, *Garaventa 2101* (CONC); Quillota, Limache, en el jardín de la casa, *Garaventa 2101* (SGO); San Isidro, 95 m, *Matthei & Quezada 374* (CONC). **Región Metropolitana:** Santiago, 1935, *Espinosa s.n.* (SGO); Cerro San Cristóbal, 750 m, *Gunckel 36816* (CONC), Cerro San Cristóbal, 750–760 m, *Gunckel 36817* (CONC); El Canelo, 700 m, *Gunckel 41737* pro parte (CONC); La Pintana, 550 m, *Gunckel 52751* (CONC); Laguna Pudahuel, 470 m, 1954, *Arriagada s.n.* (CONC); Los Cerrillos, 510 m, *Gunckel 28825* (CONC); Marruecos, 430 m, *Gunckel 28750* (CONC); Melipilla, 175 m, 1960, *Gunckel s.n.* pro parte (CONC); Quebrada de Macul, 850 m, *Levi 1045* (CONC); Quebrada de Peñalolén, 1300 m, *Bravo 289* (CONC); Quebrada del Yeso, 2000 m, 1986, *Araya s.n.* (CONC); Quebrada del Yeso, 2000 m, *Araya 47* (CONC); Quinta Normal, 1968, *Castro s.n.* (SGO); Quinta Normal, 520 m, *Schlegel 480* (CONC); S.N. Yerba Loca, ladera SW del estero Yerba Loca, 1700 m, *Arroyo & Humaña 99866* (CONC); S.N. Yerba Loca, entre Quebrada El Manzano y Villa Paulina, 1850 m, *Arroyo & Humaña 991607* (CONC); San José de Lo Arcaya, 540 m, *Bobadilla 305* (CONC); lecho del Río Mapocho, 550 m, 1954, *Arriagada s.n.* (CONC). **Región de O'Higgins:** Colchagua, Termas del Flaco, 1430 m, *Bayer 4656* (CONC). **Región del Bío-Bío:** Concepción, 10 m, *E. Barros 1825* (CONC); Desembocadura del río Bío-Bío, 5 m, *Ricardi 886* (CONC); Barrio Universitario, 50 m, *Pfister 335, 337, 340* (CONC); Calle Cochrane entre Paicaví y Janequeo, 10 m, *López 294* (CONC); La Toma, 60 m, 1945, *Pfister s.n.* (CONC, SGO); Hualpén, 60 m, *Gunckel 10062* (CONC); Parque Hualpén, 60 m, *Carrasco 381 295* (CONC); Ñuble, Ninhue, Hacienda San Agustín de Puñual, 130 m, *Finot & Riquelme 733* (CONC-CH). **Región de la Araucanía:** Cautín, Cherquenco, 200 m, *Gunckel 20302* (CONC).

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NEW COMBINATIONS, NEW SYNONYMS, AND TYPIFICATIONS IN *PSEUDOGNAPHALIUM* (ASTERACEAE: GNAPHALIEAE) FROM SOUTH AMERICA

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ABSTRACT

Four new combinations are proposed in order to have these names available for the treatment of *Pseudognaphalium* in Chile and for the Flora of Argentina: **Pseudognaphalium aldunateoides** (J. Rémy) C. Monti, N. Bayón & S.E. Freire, **Pseudognaphalium andicola** (Phil.) C. Monti, N. Bayón & S.E. Freire, both from Argentina and Chile, **Pseudognaphalium glanduliferum** (Griseb.) C. Monti, N. Bayón & S.E. Freire, from Argentina, and **Pseudognaphalium perpusillum** (Phil.) C. Monti, N. Bayón & S.E. Freire, from Chile. Two taxa are newly synonymized: *G. phaeolepis* Phil. with *G. aldunateoides* J. Rémy, and *G. diminutivum* Phil. with *G. perpusillum* Phil. Lectotypes are here proposed for: *Gnaphalium andicola*, *G. diminutivum* Phil. and *G. phaeolepis* Phil. Additionally, a table featuring diagnostic characters to distinguish between *Gnaphalium* and *Pseudognaphalium* is provided as well as illustrations of phyllaries, achenes, and pappus bristles for each species.

RESUMEN

Se proponen cuatro nuevas combinaciones, a fin de tener disponibles estos nombres para el tratamiento de los *Pseudognaphalium* de Chile y de la Flora de Argentina: **Pseudognaphalium aldunateoides** (J. Rémy) C. Monti, N. Bayón & S.E. Freire, **Pseudognaphalium andicola** (Phil.) C. Monti, N. Bayón & S.E. Freire, ambos de Argentina y Chile, **Pseudognaphalium glanduliferum** (Griseb.) C. Monti, N. Bayón & S.E. Freire, de Argentina, y **Pseudognaphalium perpusillum** (Phil.) C. Monti, N. Bayón & S.E. Freire, de Chile. Se cita a *G. phaeolepis* Phil. como nuevo sinónimo de *G. aldunateoides* J. Rémy, y a *G. diminutivum* Phil. como nuevo sinónimo de *G. perpusillum* Phil. y se designan lectotipos para: *Gnaphalium andicola*, *G. diminutivum* Phil. y *G. phaeolepis* Phil. Adicionalmente, se incluyen ilustraciones de filarios, aquenios y pelos del papus para cada especie y una tabla comparativa para distinguir por sus caracteres diagnósticos los géneros *Gnaphalium* y *Pseudognaphalium*.

South American species of *Pseudognaphalium* Kirp. have been typically treated as *Gnaphalium* L. (Cabrera 1963, 1971, 1974, 1978; Dillon & Sagástegui-Alva 1991a, b; Freire 1995, 1998; Bayón 2009). They correspond to the Achyroclinoid cudweeds group (Drury 1970). However, studies of detailed morphological characters (Hilliard & Burtt 1981) and studies based on cladistic analysis inferred from morphology (Anderberg 1991) and recent results from molecular studies (Bayer et al. 2007; Ward et al. 2009) have been interpreted as providing support for recognizing Achyroclinoid cudweeds group as a distinct genus *Pseudognaphalium* (e.g., Hilliard 1983, for South African species; Nesom 2001, 2004, 2006; Ballard et al. 2004, for North American species;

Deble & Marchiori 2006; Hind 2011; Freire et al. 2011, for South American species).

We found four combinations necessary for a consistent treatment of the genus during the course of the revision of *Pseudognaphalium* (Monti, in prep.) and the treatment of *Pseudognaphalium* Kirp. in Chile and for the Flora of Argentina (Freire, Bayón, & Monti, in prep.).

MATERIALS AND METHODS

The study is based on herbarium material from the following herbaria (abbreviations according to Thiers 2011): CONC, CORD, LP, MCNS, MCNS, SGO, and SI. Pappus bristles were observed after boiling in water and staining with 2% safranin. Characteristics of phyllaries were observed and recorded in cleared samples using Dizeo de Strittmatter's technique (1973). Observations were carried out using a light microscope (Gemalux), equipped with a photographic camera PAL CCD. Scanning electron microscopy (SEM) imaging was carried out on achene materials that were removed from herbarium sheets, rehydrated in water and fixed in FAA (70% alcohol, formaldehyde and glacial acetic acid, 85 : 10 : 5), then dehydrated through an alcohol series of 90%:96%:100% and critical point dried using EMITECH K850. They were mounted on aluminum stubs with double adhesive tape and coated with gold. Achenes surfaces were photographed using a FEI Quanta 200 scanning electronic microscope at 20 kV.

TAXONOMY

Pseudognaphalium aldunateoides (J. Rémy) C. Monti, N. Bayón & S.E. Freire, comb. nov. *Gnaphalium aldunateoides* J. Rémy, in Gay Fl. Chil. 4:232. 1849. TYPE: CHILE: Santiago, Feb 1839, *Gay s.n.* (HOLOTYPE: P, internet image! http://dsiphoto.mnhn.fr/sonnera2/LAPI/scanL/L20100903/P00704557).

Gnaphalium phaeolepis Phil., Linnaea 33:168. 1864–1865. TYPE: CHILE: s.loc., *Frumau 63*, 1865 (LECTOTYPE, designated here: SGO 64452!; ISOLECTOTYPES: SGO 44946!, 44947!), syn. nov.

Observation 1

Gnaphalium phaeolepis Phil. and *G. aldunateoides* J. Rémy are small plants from 5 to 10 cm tall with stems branched from base, and oblong to linear leaves. According to the protologue, *Gnaphalium phaeolepis* differs from *G. aldunateoides* by its brown tipped phyllaries (vs. whitish tipped in *G. aldunateoides*). After examining the type materials, we considered this character to be within the range of variation for *G. aldunateoides*. Consequently, *Gnaphalium phaeolepis* Phil. is now considered to be a synonym of *G. aldunateoides*.

Observation 2

The type designated in the protologue of *Gnaphalium phaeolepis* Phil., "In Pascuis prope Osorno crescit" has not been located at B, F, K, LP, NY or SGO and no illustration was published with the name. The specimen "*Frumau 63*, year 1865" kept at SGO (SGO 64452), which is in accordance with the protologue and has Philippi's annotations, is here selected as the lectotype.

Observation 3

Even if Anderberg (1991) left *Gnaphalium aldunateoides* in *Gnaphalium*, we moved this taxon to *Pseudognaphalium* since it has divided stereome (Fig. 1A) as this is the primary way to differentiate between *Pseudognaphalium* and *Gnaphalium*.

Pseudognaphalium andicola (Phil.) C. Monti, N. Bayón & S.E. Freire, comb. nov. *Gnaphalium andicola* Phil., Anales Univ. Chile 90:17. 1895. TYPE: CHILE. SANTIAGO: Las Condes, *L. Navarro s.n.* (LECTOTYPE, designated here: SGO 64481!).

Observation

Philippi (1895: 17) mentioned two syntypes in the protologue of *Gnaphalium andicola* "Las Condes, prov. Santiago, Cajón del Lontué, prov. Curicó." Both syntypes are kept at SGO: Las Condes, prov. Santiago, *Lautaro Navarro*, SGO 64481 (sub SGO 64384 in Muñoz Pizarro 1960: 141) and Cajón de Lontué, prov. Curicó, Januari 1882, SGO 64385. We selected as lectotype SGO 64481, which presents the most complete plant and matches the description in the protologue.

Pseudognaphalium glanduliferum (Griseb.) C. Monti, N. Bayón & S.E. Freire, comb. nov. *Gnaphalium glandu-*

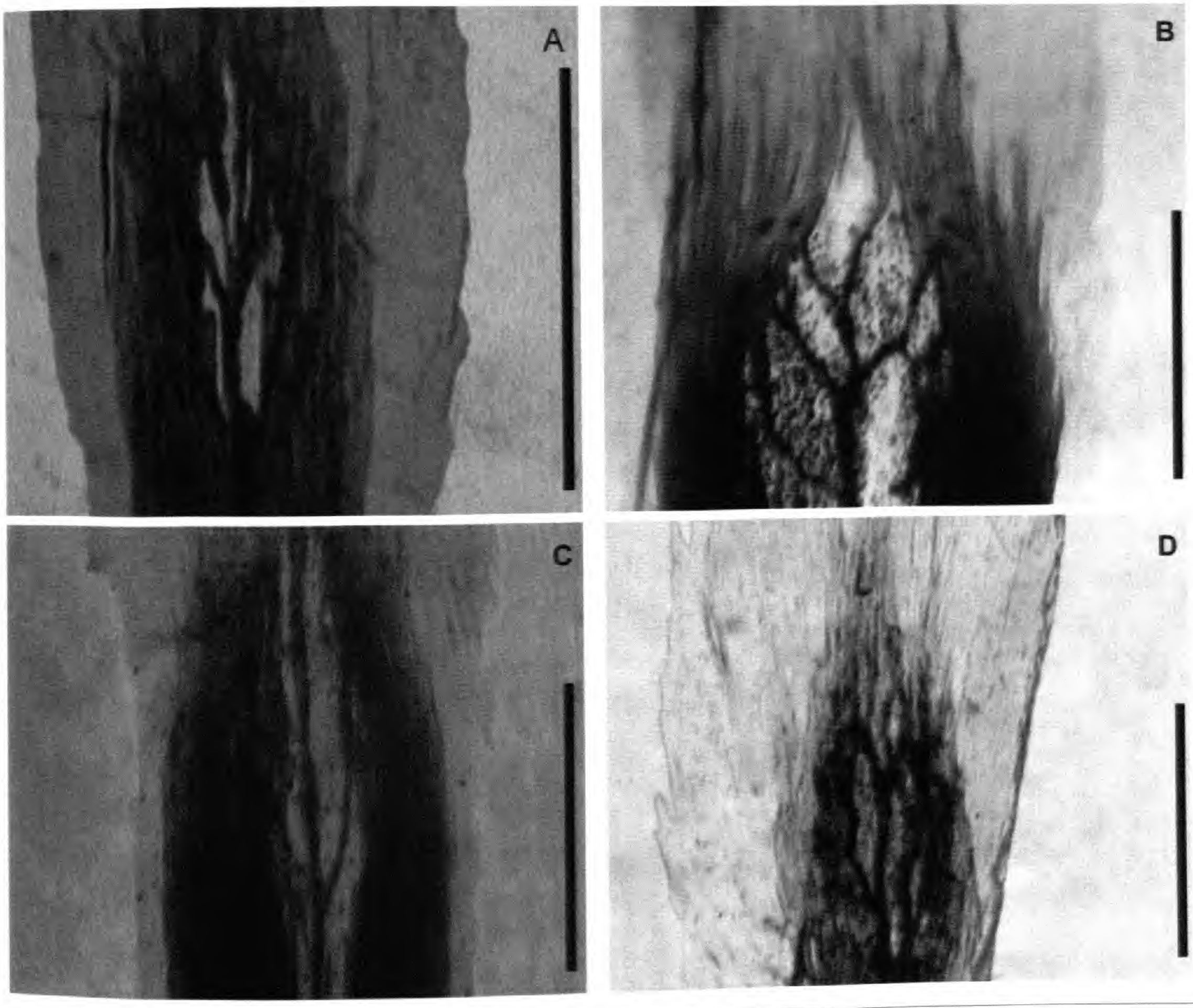


Fig. 1. Phyllaries showing the divided stereome. **A.** *Pseudognaphalium aldunateoides* (*Matthei & Quezada 1420*, CONC). **B.** *P. andicola* (*Teillier & Márquez 5315*, CONC). **C.** *P. glanduliferum* (*Hunziker 19195*, CORD). **D.** *P. perpusillum* (*Teillier 5112*, CONC). Scale bars: A–D = 0.5 mm.

liferum Griseb., Abh. Königl. Ges. Wiss. Göttingen 24:186. 1879, non Sch. Bip. Type: ARGENTINA. Salta: Alrededores de los Potreros al pie del Nevado del Castillo, 24 Mar 1873, *P.G. Lorentz & G.H.E.W. Hieronymus 146* (holotype: GOET, internet image! https://gwdu64.gwdg.de/pls/herbar/typen$typen.QueryViewByKey?P_ID=6236&Z_CHK=5074; isotypes: B (probably destroyed), internet image! http://plants.jstor.org/specimen/f0bn015098, CORD, internet image! http://plants.jstor.org/specimen/cord00006463, LP!).

Observation

The name *Gnaphalium glanduliferum* has an earlier author, i.e. *G. glanduliferum* Sch. Bip., Bot. Zeitung (Berlin) 3:173. 1845, which is a synonym of *Helichrysum glanduliferum* Sch.Bip. ex Boiss., Fl. Orient. [Boissier] 3:236. 1875.

Pseudognaphalium perpusillum (Phil.) C. Monti, N. Bayón & S.E. Freire, comb. nov. *Gnaphalium perpusillum* Phil., Linnaea 29:6. 1857–1858. Type: CHILE. Coquimbo: Sotaqui, Jan 1837, *Gay 739* (holotype: SGO 64448!).

Gnaphalium diminutivum Phil., Linnaea 33:167. 1864–1865. Type: CHILE. Colchagua: Cerro del Volcán, Feb 1861, *W. Diaz s.n.* (lectotype, designated here: SGO 64454!; isolectotype: SGO 44923!), nov. syn.

Observation 1

Gnaphalium diminutivum Phil. and *G. perpusillum* Phil. are small plants from 1 to 5 cm tall with simple stems, and linear leaves. According to the protologue, *Gnaphalium diminutivum* differs from *G. perpusillum* by its longer stems ca. 2.5 cm alt. (vs. 1.5 cm alt in *G. perpusillum*). After examining the type materials, we considered this character to be within the range of variation for *G. perpusillum*. Consequently, *Gnaphalium diminutivum* Phil. is now considered to be a synonym of *G. perpusillum*.

Table 1. Morphological comparison between *Gnaphalium* and *Pseudognaphalium*.

	Drury (1970)		Hilliard & Burtt (1981)		Anderberg (1991)	
Characters	***Gnaphalium*** (Gnaphalioid cudweeds subgroup b)	***Achyrocline*** & Achyroclinoid cudweeds	***Gnaphalium*** *(incl. Gamochaeta)*	***Pseudognaphalium***	***Gnaphalium***	***Pseudognaphalium***
Capitula arrangement	terminal and axillary leafy clusters	leafless clusters in corymbs or panicles	terminal and axillary leafy clusters	clusters in corymbs	few capitula in clusters sometimes leafy	small clusters in loose corymbs
Phyllary lamina	polychromous	monochromous	—	—	polychromous	monochromous
Phyllary stereome	undivided or with thin streak	divided	undivided or with thin streak	divided	undivided	divided
Corolla of bisexual florets	yellow with red-purple teeth	yellowish	—	—	yellow with red-purple teeth	yellow
Achenial epidermis	smooth	with imbricate papillae	—	with imbricate papillae	papillate	smooth or with imbricate papillae
Achenial hairs	elongate myxogenic	normally glabrous	glabrous or with duplex hairs	glabrous or with duplex hairs	glabrous or with clavate duplex hairs	glabrous or with clavate duplex hairs
Pappus (tip cells)	pointed or subclavate	subclavate	mono or dimorphic	monomorphic (subclavate)	dimorphic (bisexual florets subclavate)	monomorphic (subclavate)
Pappus (base)	without cilia	with cilia	nude or with small cilia	with cilia	with cilia	with cilia

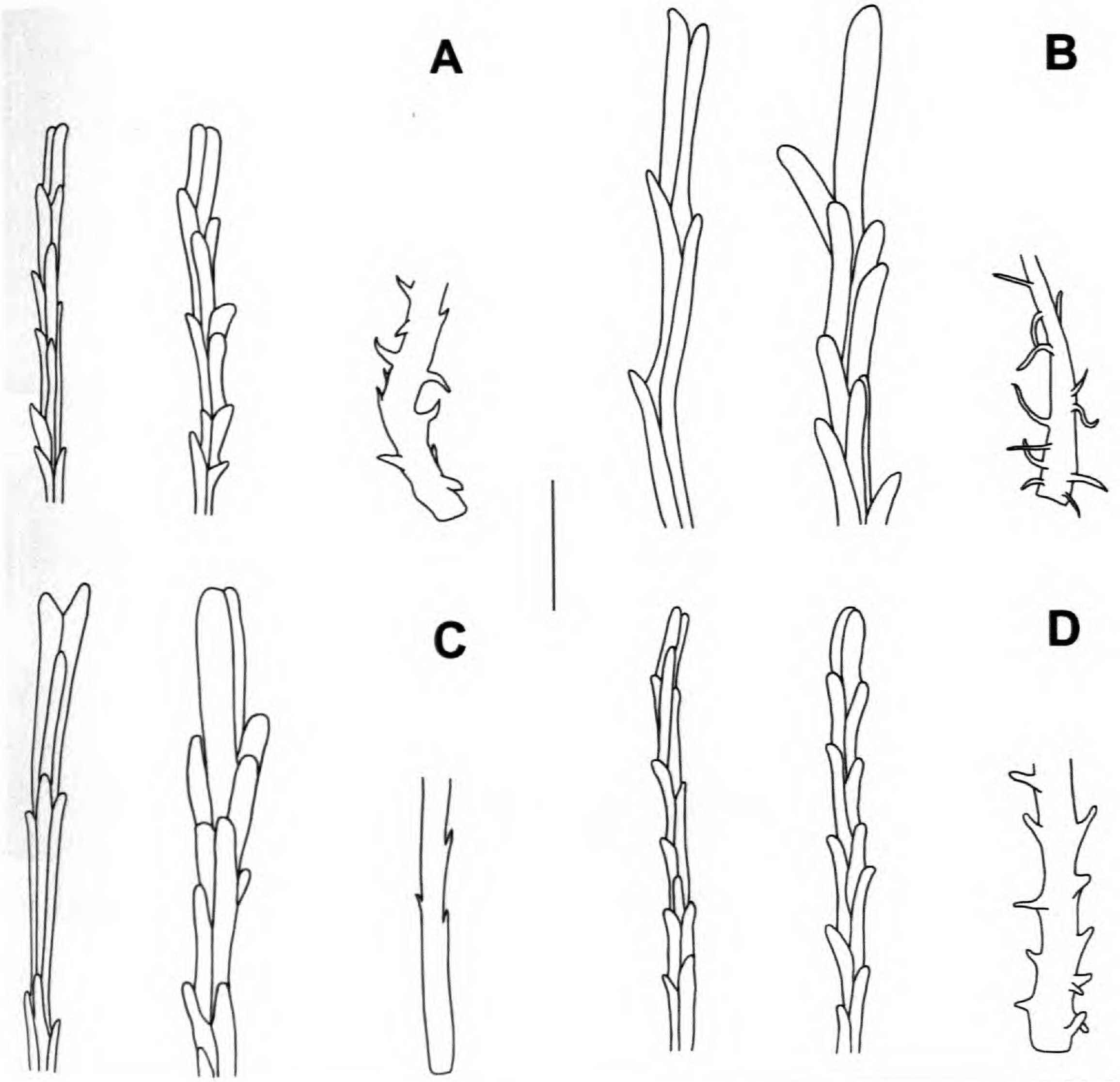


Fig. 2. Pappus bristles showing tip cells and basal portion (left to right: pappus bristle of female floret, pappus bristle of bisexual floret, basal portion of female and bisexual florets). **A.** *Pseudognaphalium aldunateoides* (*Urtubey et al. 700*, SI). **B.** *P. andicola* (*Burkart 9491*, SI). **C.** *P. glanduliferum* (*Hunziker 19195*, CORD). **D.** *P. perpusillum* (*Teillier & Márquez 5316*, CONC). Scale bar: A–D = 0.1 mm.

Observation 2

Even if no herbarium was mentioned for the type specimen in the protologue of *Gnaphalium perpusillum*, according to Stafleu and Cowan (1979), Philippi's types are found in herbarium SGO.

Observation 3

Philippi (1864: 167) mentioned in the protologue of *Gnaphalium diminutivum* "Cerro del Volcan ad originem fluvii Tinguiguirica". Because there are two sheets kept at SGO for type collection of *G. diminutivum*, we propose the specimen SGO 64454 as lectotype, which presents the most complete plants, and matches the description in the protologue.

DISCUSSION

In his classificatory study of the genus *Gnaphalium* as currently defined, Drury (1970) recognizes two extraneous elements: achyroclinoid and anaphalioid cudweeds.

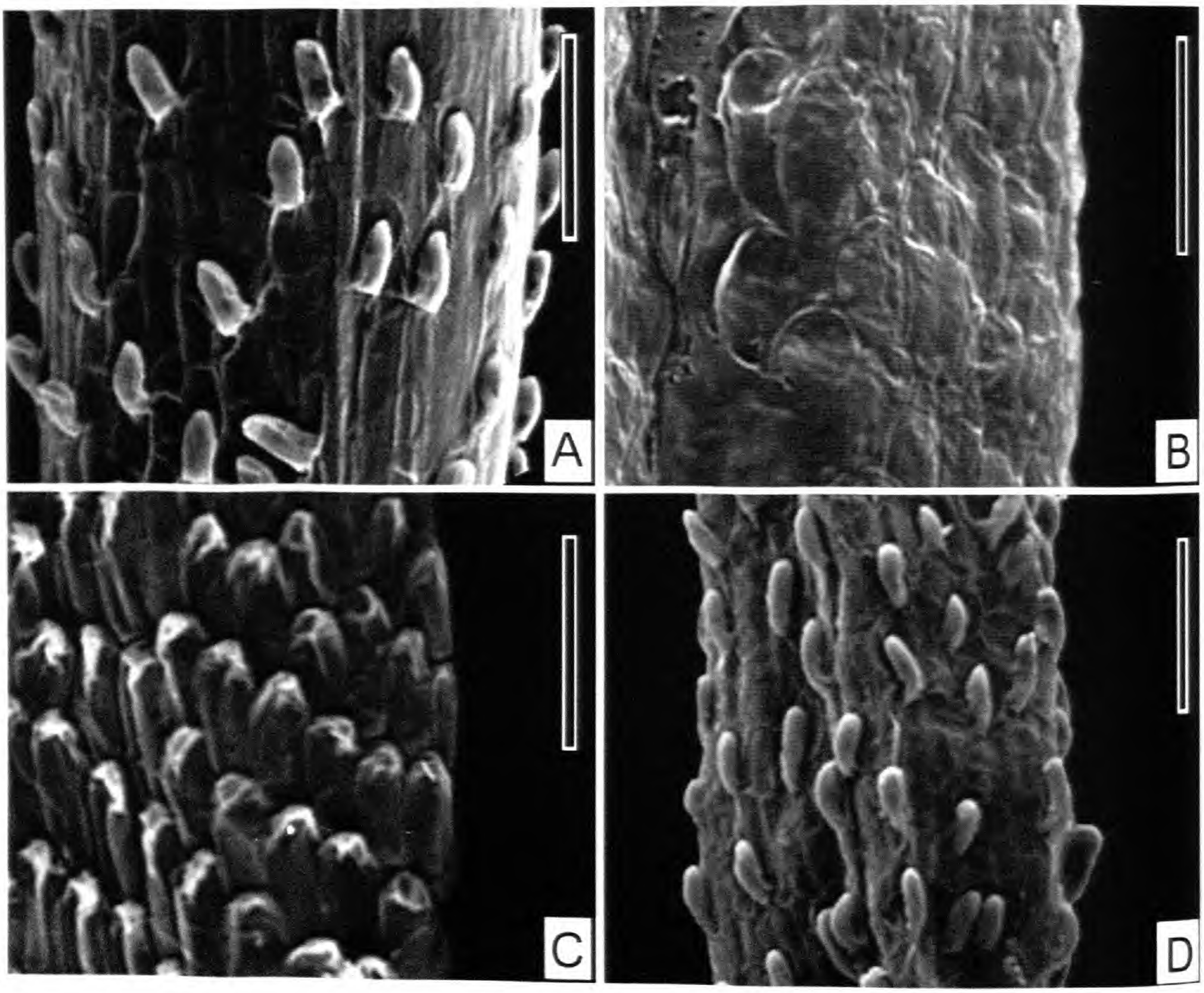


Fig. 3. Achenes. A, D, Achenes with duplex hairs; B, C, Surface view of imbricate achenial papillae. **A.** *Pseudognaphalium aldunateoides* (*Mihoc et al. 6227*, CONC). **B.** *P. andicola* (*Teillier & Márquez 5315*, CONC). **C.** *P. glanduliferum* (*Novara et al. in 1980*, MCNS). **D.** *P. perpusillum* (*Teillier 5112*, CONC). Scale bars: A–D = 50 µm

The former was characterized by having monochromous phyllaries with divided stereomes, yellowish florets, pappus bristles subclavate at the tip with bases cohering by patent cilia, papillate achenes and capitula arranged in corymbs or panicles. Subsequently, Hilliard and Burtt (1981), following Drury (1970), transferred nine South African species from *Gnaphalium* to the monotypic genus *Pseudognaphalium* Kirp. Anderberg (1991), in his worldwide revision of Gnaphalieae, also recognized the genus *Pseudognaphalium* and added more than 70 species to it. Morphological comparison between *Gnaphalium* and *Pseudognaphalium* is shown in Table 1.

In this paper, four species are transferred from *Gnaphalium* to *Pseudognaphalium* owing to monochromous phyllaries with divided stereomes (Fig. 1); monomorphic (or slightly dimorphic) pappus bristles, subclavate at the tip (Fig. 2); clusters of capitula arranged in corymbs; achenial epidermis glabrous and papillate (*P. andicola* and *P. glanduliferum*, Fig. 3); or oblong duplex myxogenic hairs (*P. aldunateoides*, *P. perpusillum*, Fig. 3). These traits are considered to be diagnostic features for *Pseudognaphalium* (Anderberg 1991). However, the corollas with red purple teeth of two species (*P. aldunateoides*, *P. perpusillum*), and pappus bristles smooth at the base of *P. glanduliferum* (Fig. 2), do not match the features of *Pseudognaphalium* (Anderberg 1991).

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DIFERENCIACIÓN DE ESPECIES ARGENTINAS DE *CLINOPODIUM* (LAMIACEAE: NEPETOIDEAE) A TRAVÉS DE CARACTERES MORFOLÓGICOS Y ANATÓMICOS DE SUS FRUTOS

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RESUMEN

Se realizó un estudio integral comparado de los frutos de las especies de *Clinopodium* (Lamiaceae: Nepetoideae: Mentheae: Menthinae) nativas de Argentina, con los siguientes objetivos: a) caracterizar su exomorfología y anatomía; b) correlacionar la estructura del pericarpo con el fenómeno de mixocarpia; c) valorar la incidencia de los caracteres carpológicos para diferenciar las especies. Las observaciones se efectuaron con microscopía óptica y electrónica de barrido. La forma, el tamaño, la ornamentación de la superficie, el indumento y la forma del hilo cárpico fueron los caracteres exomorfológicos de mayor valor diagnóstico. Se comprobó la presencia del fenómeno de mixocarpia en el género pero no fue constante para todas las especies analizadas. La estructura del pericarpo puso en evidencia dos patrones anatómicos en el epicarpo que se asocian a la producción de mucílagos en tanto que la región externa del mesocarpo es distinta según se trate de especies mixocárpicas o no. En base a los resultados obtenidos se discuten algunas consideraciones taxonómicas.

PALABRAS CLAVES: Lamiaceae, *Clinopodium*, Argentina, frutos, exomorfología, histología, mixocarpia

ABSTRACT

Differentiation of Argentinean *Clinopodium* (Lamiaceae: Nepetoideae) species through morphological and anatomical fruits characters. An integral study of fruits belonging to native Argentinean species of *Clinopodium* (Lamiaceae: Nepetoideae: Mentheae: Menthinae) has been made with the following aims: a) to characterize its exomorphology and anatomy; b) to correlate the pericarp structure with the phenomenon of the myxocarpy; c) to assess the incidence of the carpological characters to differentiate the species. Observations have been carried out using light and scanning electron microscope. Shape, size, surface ornamentation, indumentum and shape of abscission scar were the most diagnostic value features. Myxocarpy was proved in the genus but this phenomenon is not consistent in all the studied species. The pericarp structure revealed two anatomical patterns, each one associated with the production of mucilage, whereas the outer region of the mesocarp varies according to the species. Some taxonomical considerations have been discussed.

KEY WORDS: Lamiaceae, *Clinopodium*, Argentina, fruits, exomorphology, histology, myxocarpy

INTRODUCCIÓN

Clinopodium L. (tribu Mentheae, subtribu Menthinae) consta de ca. 100 especies circunscritas en su mayoría a América (desde Canadá hasta Chile y Argentina) y a Eurasia templada. En la moderna concepción de este género, se incluyen a las especies de *Satureja* L. del Nuevo Mundo, quedando este último restringido a Eurasia y África (Harley & Granda Paucar 2000; Harley et al. 2004). Acorde a Bräuchler et al. (2010) tal circunscripción hace de *Clinopodium* el género taxonómicamente más difícil y morfológicamente más diverso dentro de la subtribu Menthinae. Estos autores realizan la filogenia de esta subtribu, analizando 48 especies de *Clinopodium* y demostrando que las especies de este género no forman un grupo monofilético; por lo tanto, su circunscripción actual resulta muy poco natural.

En Argentina, habitan cinco especies nativas de *Clinopodium*: *C. bolivianum* (Benth.) Kuntze subsp. *tarijense* (Weddell ex Griseb.) J.R.I. Wood, *C. gilliesii* (Sw.) Kuntze y *C. odorum* (Griseb.) Harley de la zona serrana del centro y noroeste del país, *C. brownei* (Sw.) Kuntze del litoral y, *C. darwinii* (Benth.) Kuntze de la estepa patagónica (Harley 2008).

Diversos autores destacan la importancia taxonómica y filogenética del pericarpo en Lamiaceae a distin-

tos niveles jerárquicos, junto a otros caracteres florales, palinológicos y seminales (Cantino et al. 1992; Ryding 1994, 1995, 2010; Moon et al. 2009). Según Ryding (1994), algunos caracteres de los frutos, particularmente aquellos del esclerénquima, son algo conservativos a niveles supragenéricos pero son consistentes dentro del género.

Harley et al. (2004) describen de manera general la exomorfología de los frutos de *Clinopodium* en tanto que otros autores han estudiado la anatomía de un total de 8 especies, incluyendo a *C. bolivianum* (Wojciechowska 1966; Ryding 1995, 2010; Duletić-Laušević & Marin 1999; Martín Mosquero et al. 2004). Por su parte, Moon et al. (2009) proponen un análisis filogenético de las Mentheae utilizando caracteres de los frutos observados con microscopía electrónica de barrido; en dicho estudio, *C. vulgare* L. y *C. nepeta* (L.) Kuntze son los representantes de *Clinopodium*. Datos exomorfológicos de *C. vulgare* fueron también reportados por Wojciechowska (1966) y Husain et al. (1990).

La mixocarpia, fenómeno debido a la presencia de células mucilaginosas en el epicarpo, es otro carácter relevante en la subfamilia Nepetoideae, habiéndose reportado que casi el 70% de las especies poseen frutos mucilaginosos (Ryding 1994). Según Ryding (2001), se pueden presentar tres situaciones distintas: géneros exclusivamente no mixocárpicos, como ocurre en *Alvesia* Welw., *Holostylon* Robyns & Lebrun (Ryding 1992) y *Lepechinia* Willd. (Scandaliaris & Barboza 2011); géneros exclusivamente mixocárpicos como por ejemplo *Lavandula* L. (Ryding 1992) y, géneros con especies mixocárpicas y no mixocárpicas, caso de *Hyptis* Jacq. y *Ocimum* L. (Ryding 1992). Cuando existe mixocarpia, las células que producen mucílago se pueden hinchar sin liberar el mucílago o bien éste queda totalmente expuesto. En *Clinopodium*, la mixocarpia no fue mencionada para las especies estudiadas por Ryding (2010) mientras que Duletić-Laušević & Marin (1999) y Moon et al. (2009) comprueban la ausencia de este fenómeno en *C. vulgare y C. nepeta*.

Con respecto a las especies argentinas, la información sobre los caracteres morfológicos y anatómicos de los frutos es mas que fragmentaria (Wood 2011). En cambio, cuatro de estas especies (*C. odorum* no incluida) han sido incorporadas en el análisis molecular realizado por Bräuchler et al. (2010), apareciendo en clados distintos y emparentadas con especies sudamericanas de otros géneros.

En base a estos antecedentes y como parte de un trabajo integral sobre la carpología de las especies de Lamiaceae nativas de Argentina, los objetivos de este trabajo fueron: a) describir las especies de *Clinopodium* nativas de Argentina a través de los caracteres exomorfológicos y anatómicos de sus frutos; b) correlacionar la estructura del pericarpo con el fenómeno de mixocarpia; c) valorar la incidencia de los caracteres carpológicos para diferenciar las especies.

MATERIAL Y MÉTODOS

Material vegetal

Se trabajó con material de herbario (ACOR, CORD, CTES, LIL y SI) y con muestras que se recolectaron a campo. Frutos de estos últimos se fijaron en solución FAA (solución de formol, acohol etílico 96%, ácido acético y agua, en proporción de 2:10:1:7) por 48 hs, y luego se guardaron en alcohol etílico al 70% hasta su utilización. Los materiales herborizados se depositaron en el herbario ACOR y CORD.

Especímenes examinados: *Clinopodium bolivianum* subsp. *tarijense*: **ARGENTINA. Jujuy. Depto. Capital:** Quebrada de Chijran, camino a Tilquiza, 22 Sep 1991, *Guaglianone 2769* (CTES); Los Morados, 31 Ene 1981, *Ahumada 4271* (CTES). **Salta. Depto. Capital:** Quebrada de San Lorenzo, junto al cauce del arroyo, 30 Ago 1977, *Novara et al. 431* (CORD). *Clinopodium brownei*: **ARGENTINA. Corrientes. Depto. Curuzú Cuatiá:** Río Mocoretá, en monte marginal, 22 Oct 1971, *Burkart et al. 2838* (SI). **Depto. Goya:** Colonia San José, 20 km al S de Goya, 27 Nov 1979, *Schinini 19313* (CTES). **Depto. San Luis del Palmar:** 35 km SE de San Luis del Palmar, 2 Nov 1975, *Cristóbal 1412* (CTES). **Depto. Santo Tomé:** Caza Pava, 18 Nov 1944, *Ibarrola 1317* (LIL). *Clinopodium darwinii*: **ARGENTINA. Neuquén. Depto. Zapala:** por RN 40, 20 km antes de Zapala, viniendo desde Catán Lil, 30 Ene 2010, *Barboza et al. 2814* (CORD). **Río Negro. Depto. Valcheta:** Laguna Azul a Cerro Puntudo, 27 Ene 2002, *Troiani et al. 15478* (CTES). **Santa Cruz. Depto. Güer Aike:** RN 40, Estancia El Tero, 31 Ene 2003, *Cocucci et al. 2526* (CTES). *Clinopodium gilliesii*: **ARGENTINA. Catamarca. Depto. Ambato:** Sierra de Ambato (Falda E, subiendo desde El Rodeo hacia El Manchado) cerca de la Casa de Piedra del primer campo, 22 Feb 1971, *Hunziker 20982* (CORD). **Córdoba. Depto Punilla:** Por el camino viejo desde Copina rumbo a El Cóndor, a ca. 12,9 km del Río Las Suelas, 21 Dic 2004, *Barboza et al. 1116* (CORD); Camino Copina-Cóndor, entre cuarto y quinto puente colgante, 9 Feb 2010, *Proyecto Colección de Semillas (CS) 1418* (ACOR). *Clinopodium odorum*: **ARGENTINA. Córdoba. Depto. Punilla:** Sierra Chica, Cerro Uritorco, falda occidental, 15 Ene 1965, *Hunziker 18024* (CORD); Camino Copina – Cóndor, entre cuarto y

quinto puente colgante, 9 Feb 2010, *Proyecto Colección de Semillas (CS) 1417* (ACOR); Sierra Grande (falda E), entre El Cóndor y Copina, 5 Mar 1992, *Zygadlo 146* (CORD).

METODOLOGÍA

Estudios exomorfológicos

Se realizaron fotografías con microscopio electrónico de barrido (MEB) para lo cual se seleccionaron frutos maduros que fueron montados en discos de aluminio con cinta adhesiva doble faz. Las muestras se bañaron con oro y se observaron en un microscopio JEOL JSM 35 CF, en el Laboratorio de Microscopía y Microanálisis de la Universidad Nacional de San Luis (Argentina). Además, se efectuaron extendidos del epicarpo que se colorearon con safranina para observar el ordenamiento de las células en vista superficial.

Los aspectos analizados fueron: 1) tamaño, 2) forma en vista dorsal y ventral, 3) simetría, 4) color, 5) ordenamiento de las células en vista superficial, 6) ornamentación de la superficie al MEB, 7) ubicación y forma del hilo cárpico, 8) presencia y tipo de ceras.

Para estimar el tamaño de los frutos, se midió el ancho y el largo en 3 muestras de 15 frutos por cada una y por especie en tanto que para la forma se tomó como referencia a Stearn (1983). El color del pericarpo se determinó por la comparación con la carta de colores de Munsell (2000). La descripción de la superficie se realizó siguiendo los patrones establecidos por Budanstev & Lobova (1997) y Bonzani et al. (2011).

Mixocarpia

Para verificar la mixocarpia, se remojaron frutos en agua destilada por 72 horas. Posteriormente, la presencia de mucílagos se puso en evidencia utilizando azul brillante de cresilo al 1%. Se midió el ancho del halo producido y se tipificó la reacción según Bonzani et al. (2011).

Estudios anatómicos

Se realizaron preparados permanentes con los frutos fijados en FAA y con los provenientes de herbario. Se siguió la técnica de Johansen (1940) y González & Cristóbal (1997). Los frutos extraídos de ejemplares de herbario fueron previamente remojados durante 10 días en alcohol etílico 96%, glicerol y agua en partes iguales (Budanstev & Lobova 1997). Se efectuaron cortes transversales de 10–12 µm, con micrótomo de accionamiento manual. Los preparados se colorearon con safranina y azul astral. Para la observación se utilizó microscopio óptico Axiophot Zeiss, con cámara digital incluida.

Para las descripciones anatómicas, se siguió el criterio de Wojciechowska (1966) quien considera a las esclereidas como parte del mesocarpo.

RESULTADOS

Clinopodium bolivianum subsp. tarijense

Exomorfología (Figs. 1 A–F; 3 A).—Núculas de 2–2,4 × 0,45–0,5 mm. Forma obclavado-subulada curvándose hacia el ápice, de base obtusa. Asimétricas. De color marrón amarillento oscuro. Epicarpo con grandes células mucilaginosas rodeadas por pequeñas células no mucilaginosas (Fig. 3 A). Superficie al MEB espinulosa en la mitad superior, con "espinas" (tricomas) estriado-acordonados, y superficie reticulado-areolado lisa a levemente estriada en la mitad inferior. Hilo cárpico alargado y ubicado en la base hacia la cara ventral; zona perihilar con ceras de tipo cristaloide esférico.

Mixocarpia (Fig. 2 G).—Reacción moderadamente fuerte, con un halo de mucílago continuo de 0,17–0,3 mm.

Anatomía (Fig. 3 B, C).—Pericarpo de 25–32,8 µm de grosor. Epicarpo de 7,8–9,4 µm, formado por una capa de células mucilaginosas más o menos oblongas entremezcladas con células no mucilaginosas isodiamétricas a rectangulares; hacia el ápice del fruto, células no mucilaginosas isodiamétricas a alargadas tangencialmente intercaladas con tricomas bi- tricelulares no mucilaginosos, cubiertos por una gruesa capa de cutícula. Mesocarpo de 14,1–18,7 µm, formado por tres regiones: la más externa, de 1,6–3,1 µm, con una o dos capas de células aplanadas (alargadas tangencialmente) de límites difusos e intensamente teñidas; la región media unistrata, de 4,7–6,2 µm, con células parenquimáticas isodiamétricas incoloras; la región más interna también

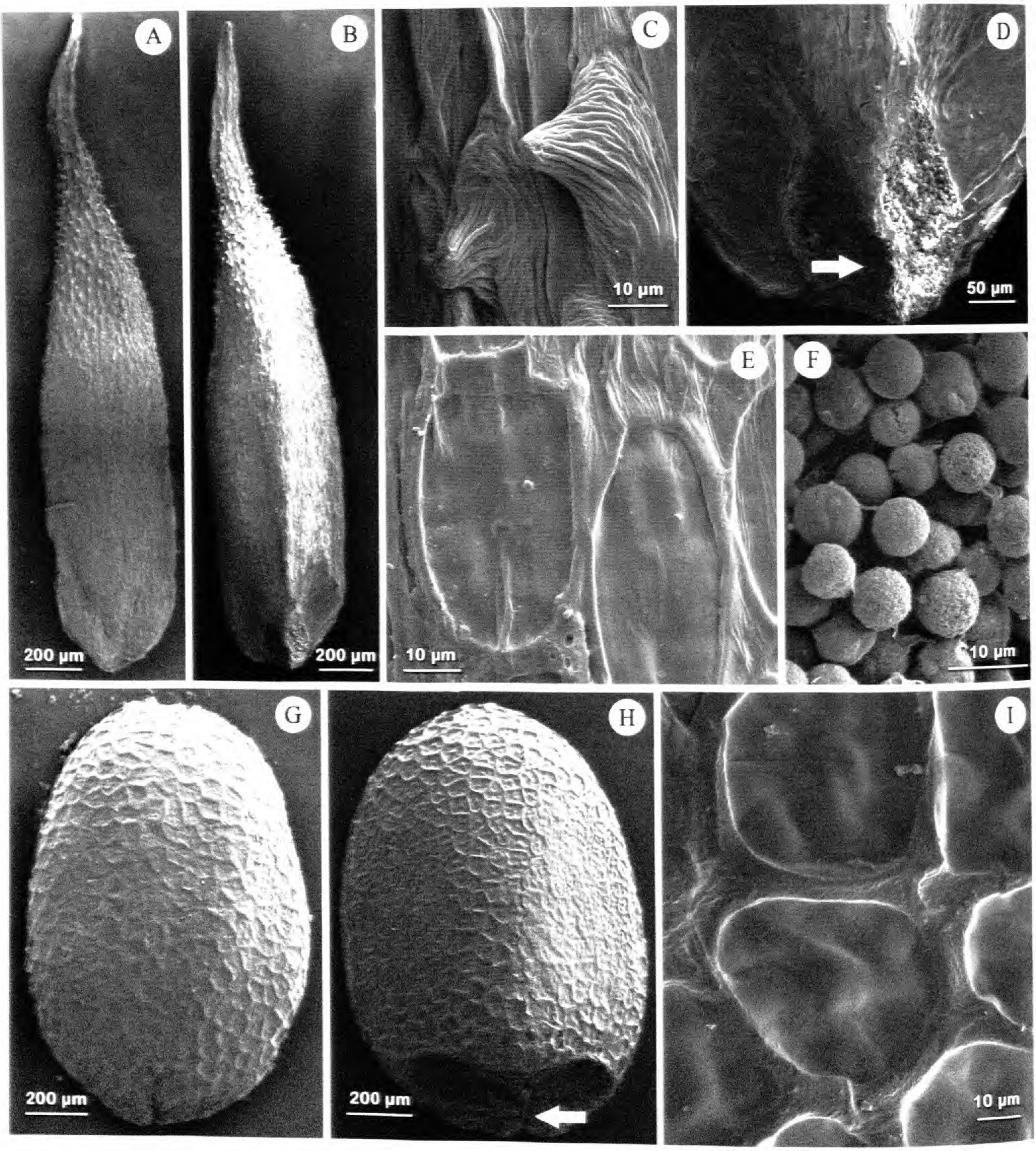


FIG. 1. Microfotografías con MEB. **A–F** *Clinopodium bolivianum* subsp. *tarijense*. **A.** Vista cara dorsal; **B.** Vista cara ventral; **C.** Detalle de los tricomas y su ornamentación; **D.** Vista zona hilar; **E.** Detalle de la ornamentación de la superficie; **F.** Detalle de ceras presentes en zona perihilar. **G–I** *C. brownei*. **G.** Vista cara dorsal; **H.** Vista cara ventral; **I.** Detalle de ornamentación de la superficie. Con flecha se muestra el hilo cárpico. (A–F de *Ahumada 4271*. G–I *de Schinini 19313*).

unistrata, de 7,8–9,4 µm, con esclereidas alargadas radialmente o más o menos isodiamétricas, de paredes engrosadas y lumen redondeado pequeño. Endocarpo unistrato, de 3,1–4,7 µm, con células oblongas y paredes con engrosamientos escalariformes.

Clinopodium brownei

Exomorfología (Fig. 1 G–I).—Núculas de 1–1,2 × 0,7–0,8 mm. Forma elipsoidea, de base y ápice redondeados, de sección más o menos trigona. Levemente asimétricas. De color marrón amarillento oscuro a marrón rojizo

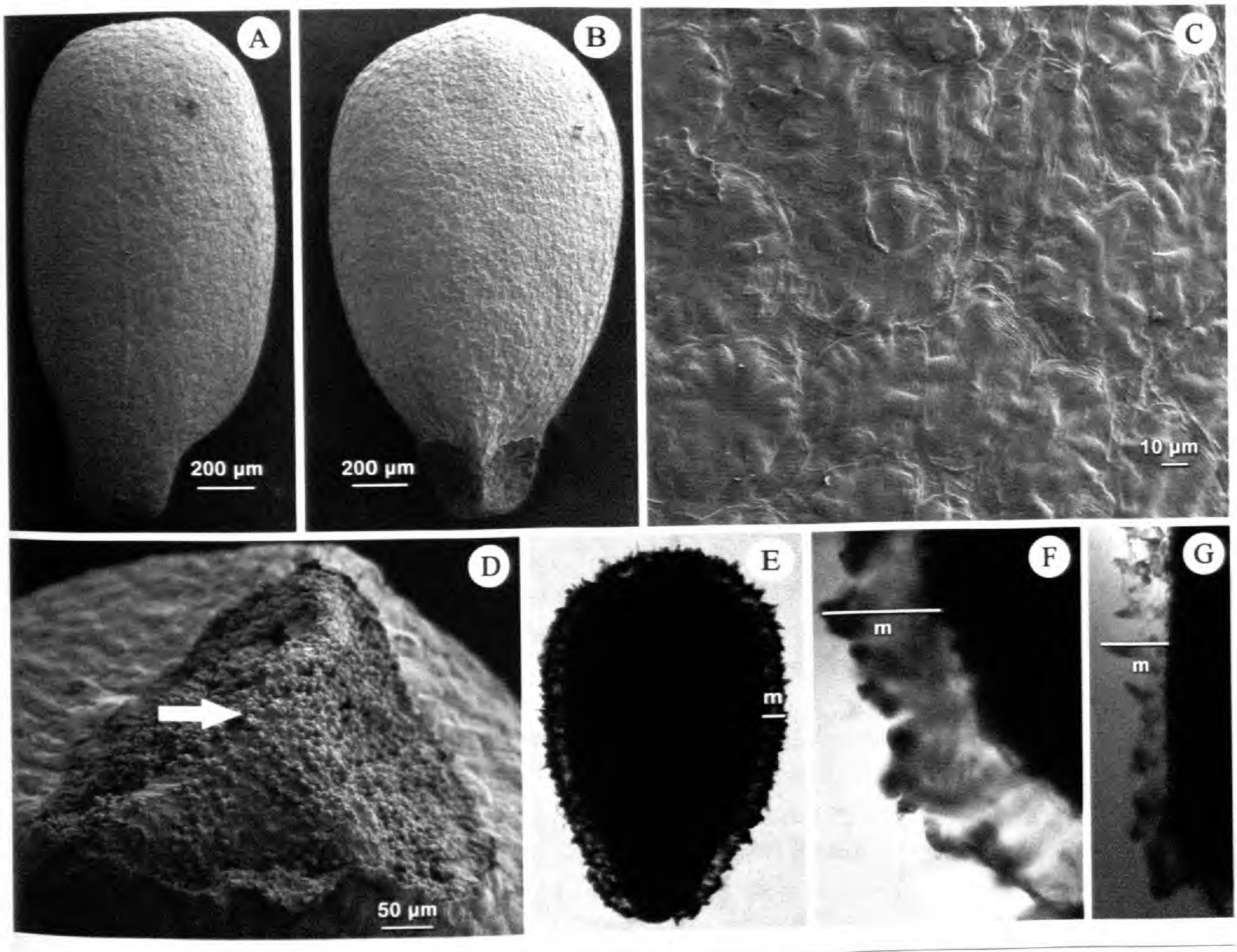


Fig. 2. A–D Microfotografías con MEB. **A–D** *Clinopodium darwinii*. **A.** Vista cara dorsal; **B.** Vista cara ventral; **C.** Detalle de ornamentación de la superficie; **D.** Vista zona hilar. **E–G** Mixocarpia. **E.** *C. darwinii*; **F.** *C. brownei*; **G.** *C. bolivianum* subsp. *tarijense*. **m.** mucílago. Con flecha se muestra el hilo cárpico. (A–F de *Cocucci et al. 2526*. G de *Schinini 19313*. H de *Ahumada 4271*)

oscuro. Epicarpo con grandes células mucilaginosas rodeadas por pequeñas células no mucilaginosas. Superficie al MEB de tipo reticulado redondeado-radiado, con estrías cuticulares radiales. Hilo cárpico triangular y ubicado en la base hacia la cara ventral; zona perihilar con ceras de tipo cristaloide esférico.

Mixocarpia (Fig. 2 F).—Reacción moderadamente fuerte, con un halo de mucílago continuo de 0,23–0,25 mm.

Anatomía.—Pericarpo de 88,9–106,2 µm de grosor. Epicarpo, de 12,5–20,3 µm, formado por una capa de células mucilaginosas en general alargadas tangencialmente entremezcladas con células no mucilaginosas alargadas radialmente. Tricomas ausentes. Mesocarpo de 74,8–84,3 µm, con tres regiones: la más externa, de 6,2–7,8 µm, con una o dos capas de células aplanadas de límites difusos e intensamente teñidas; la región media unistrata, de 3,1–4,7 µm, con células parenquimáticas aplanadas e incoloras; la región más interna unistrata, de 65,5–71,8 µm, con esclereidas alargadas radialmente de paredes engrosadas y lumen redondeado pequeño. Endocarpo unistrato, de ca. 1,6 µm, de células oblongas con paredes gruesas.

Clinopodium darwinii

Exomorfología (Fig. 2 A–D).—Núculas de 1,6–1,8 × 0,9–1 mm. Piriformes, de base truncada y ápice redondeado. Levemente asimétricas. De color marrón amarillento a marrón oscuro. Epicarpo con grandes células mucilaginosas rodeadas por pequeñas células no mucilaginosas. Superficie al MEB de tipo reticulado redondeado-radiado y estrías cuticulares concéntricas. Hilo cárpico triangular, ubicado en la base hacia la cara ventral; zona perihilar con ceras de tipo cristaloide esférico.

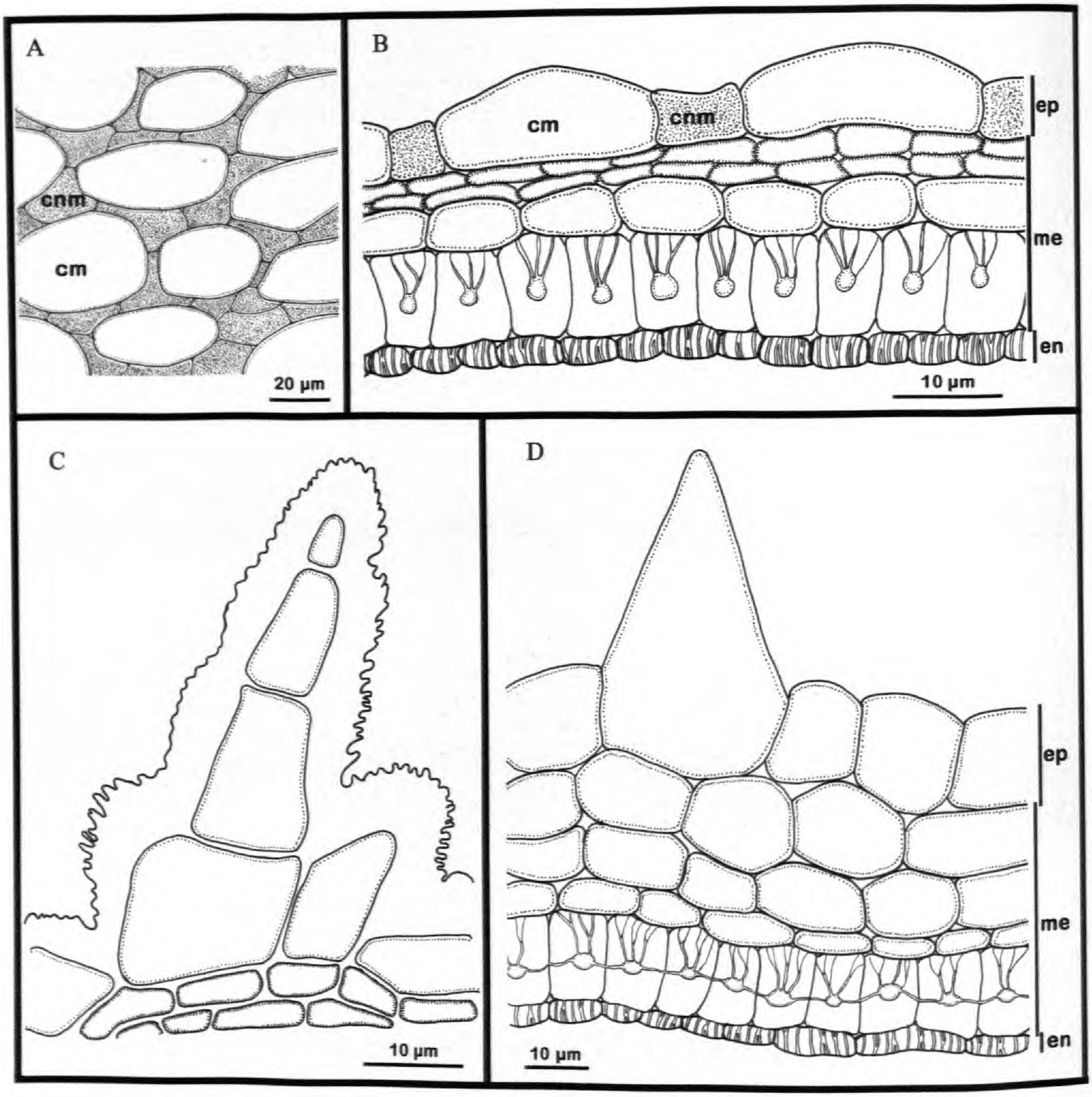


FIG. 3. Esquemas de la estructura del pericarpio. **A–C** *C. bolivianum* subsp. *tarijense*. **A.** Vista superficial del epicarpo mostrando ordenamiento de células no mucilaginosas y mucilaginosas; **B.** Estructura de pericarpo mucilaginoso; **C.** Detalle de tricoma pluricelular con gruesa cutícula; **D.** *C. odorum*, estructura de pericarpo no mucilaginoso. *Abreviaturas* cnm. células no mucilaginosas; cm. células mucilaginosas; ep. epicarpo; me. mesocarpo; en. endocarpo. (A–C de *Ahumada 4271*. D de *CS 1417*).

Mixocarpia (Fig. 2 E).—Reacción moderadamente fuerte, con un halo de mucílago continuo de 0,12–0,25 mm.

Anatomía.—Pericarpo de 29,7–45,2 µm de grosor. Epicarpo unistrato, de 4,7–7,8 µm, formado por dos tipos de células: las mucilaginosas, alargadas y más o menos ovaladas, entremezcladas con las no mucilaginosas, más pequeñas e intensamente teñidas de rojo. Tricomas ausentes. Mesocarpo de 21,9–31,2 µm, con dos regiones: la externa, de 4,7–7,8 µm, con 1 a 2 capas de células rectangulares aplanadas e intensamente teñidas de rojo; la interna, de 17,2–23,4 µm, con esclereidas en empalizada, alargadas radialmente de paredes engrosadas y lumen redondeado. Endocarpo unistrato, de 3,1–6,2 µm, con células isodiamétricas a rectangulares de paredes con engrosamientos escalariformes.

Clinopodium gilliesii

Exomorfología (Fig. 4 A–E).—Núculas de 1,1–1,3 × 0,5–0,6 mm. Forma obovoidea, ápice obtuso a redondeado y base turbinada (en forma de cono invertido), de sección trígona. Asimétricas. De color marrón intenso a marrón oscuro. Epicarpo con células y tricomas unicelulares no mucilaginosos. Superficie al MEB tuberculada, con leves estriaciones concéntricas, excepto en el ápice donde presenta tricomas estriado-acordonados. Hilo cárpico elíptico ubicado en la base hacia la cara ventral; zona perihilar con ceras de tipo cristaloide esférico.

Mixocarpia.—No produce mucílago.

Anatomía.—Pericarpo de 27,4–37,5 µm de grosor. Epicarpo de 7,8–9,4 µm, con una capa de células alargadas tangencialmente intercaladas con tricomas unicelulares dispersos. Mesocarpo de 16,5–25 µm, con 3 regiones unistratas cada una: la más externa, de células oblongas con paredes redondeadas; la media, de células rectangulares más aplanadas e incoloras; y la más interna de esclereidas alargadas radialmente, de ca. 7,8 µm, con paredes engrosadas y lumen redondeado. Endocarpo unistrato, de ca. 3,1 µm, con células rectangulares de paredes con engrosamientos escalariformes.

Clinopodium odorum

Exomorfología (Fig. 4 F–I).—Núculas de 1,4–1,5 × 0,5–0,7 mm. Forma obclavado-subulada, curvándose hacia el ápice y de base turbinada. Asimétricas. De color marrón oscuro. Epicarpo con células y tricomas unicelulares no mucilaginosos. Superficie al MEB espinulosa, las "espinas" (tricomas) estriado-acordonadas. Hilo cárpico alargado y ubicado en la base hacia la cara ventral; zona perihilar, con ceras de tipo cristaloide esférico.

Mixocarpia.—No produce mucílago.

Anatomía (Fig. 3 D).—Pericarpo de 59,2–79,9 µm de grosor. Epicarpo de 14 a 19 µm, con una capa de células oblongas a redondeadas y tricomas unicelulares. Mesocarpo de 42,1–56,2 µm, con 3 regiones: la más externa, de 23,4–31,2 µm, formada por dos capas de células parenquimáticas más o menos redondeadas con paredes delgadas; la media unistrata, de 3,1–4,7 µm, con células más o menos rectangulares e incoloras; la más interna, de 15,6–20,3 µm, con esclereidas alargadas radialmente, de paredes engrosadas y lumen redondeado a estrellado. Endocarpo unistrato, de 3,1–4,7 µm, con células parenquimáticas, aplanadas tangencialmente, de paredes con engrosamientos escalariformes.

En la Tabla 1, se muestran los caracteres exomorfológicos diferenciales de los frutos, la reacción mucilaginosa y la variación en grosor de las capas del pericarpo, para las especies estudiadas.

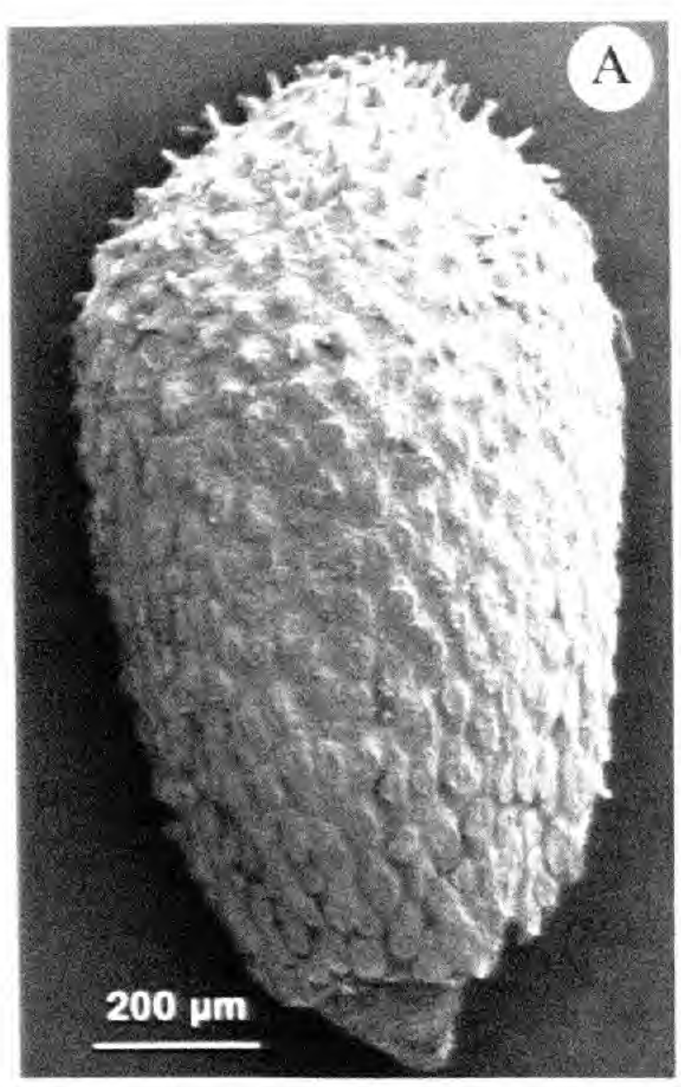
DISCUSION

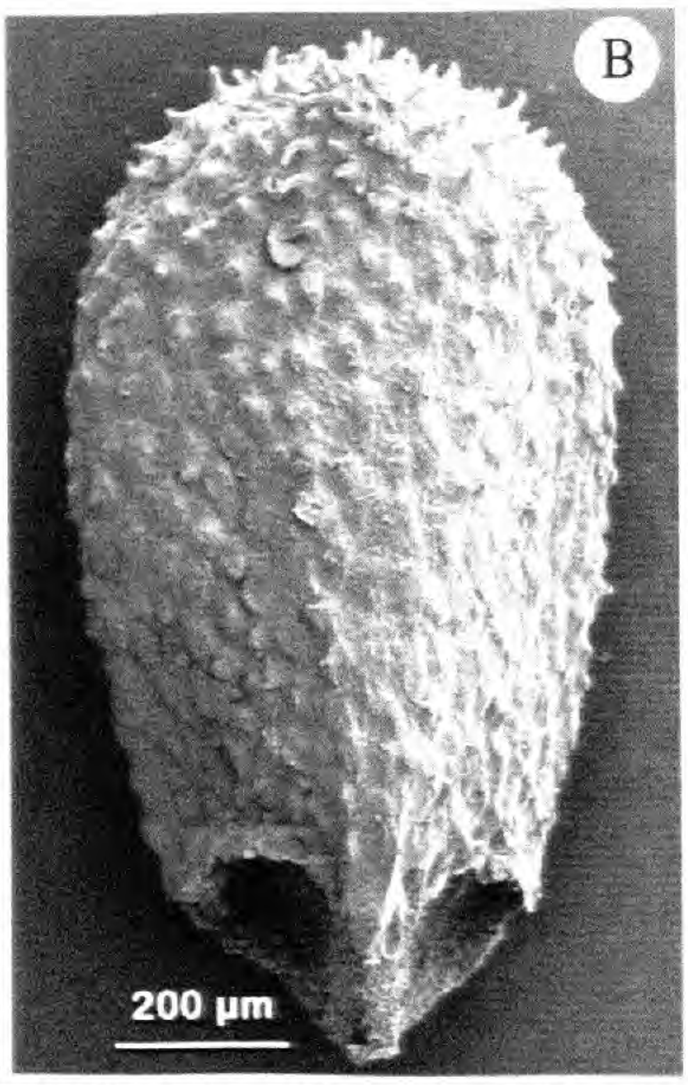
Exomorfología

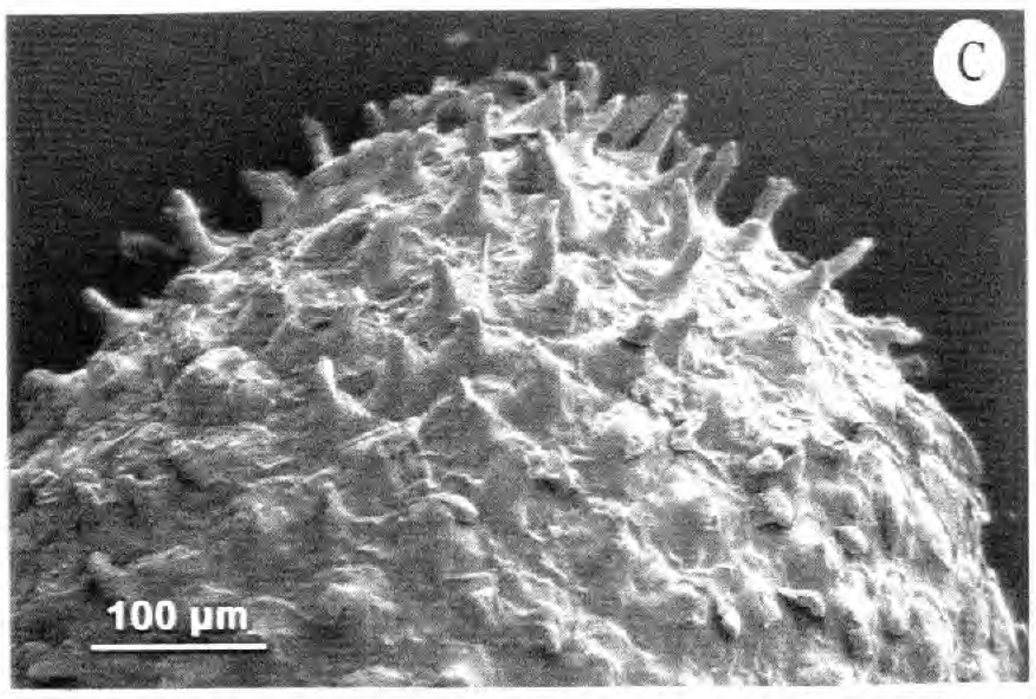
Wood (2011) señaló la forma y el indumento de los frutos como los caracteres taxonómicos más relevantes para las especies bolivianas de *Clinopodium*. Además de estos rasgos, pudimos diferenciar las especies argentinas por otros tales como el tamaño, la ornamentación de la superficie y la forma del hilo cárpico. En cambio, el color, la simetría y la posición del hilo cárpico al igual que la presencia y tipo de ceras en la región perihilar no presentaron variaciones diagnósticas a nivel específico. Martín Mosquero et al. (2004) reportó frutos simétricos para este género en contraposición a los resultados aquí presentados.

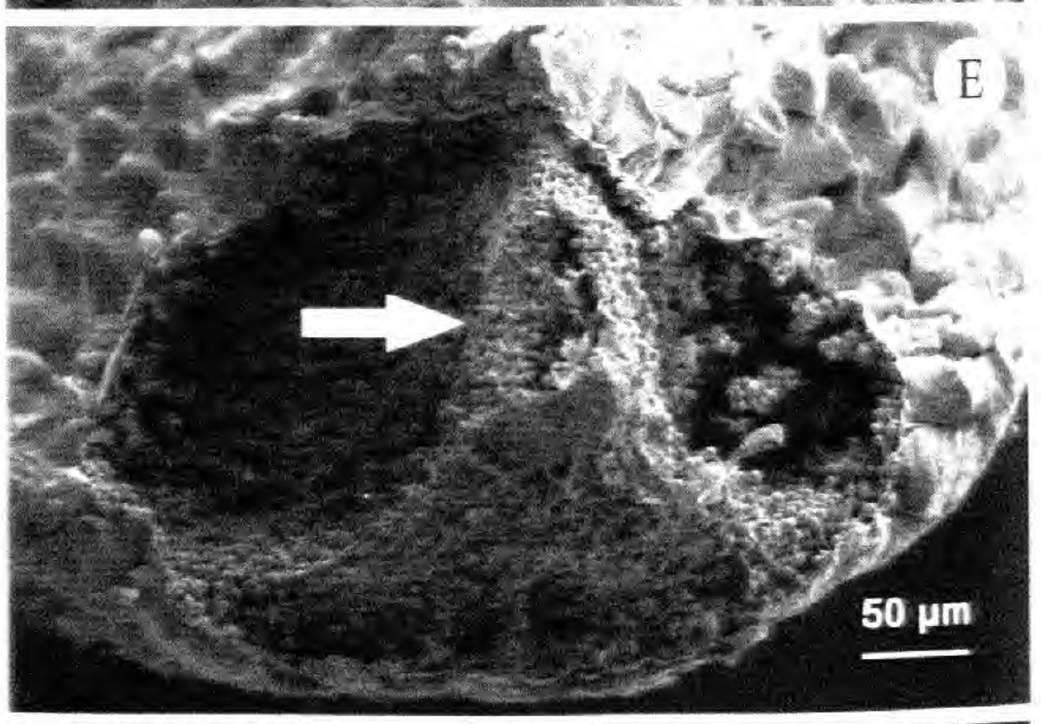
Formas elipsoideas a ovoideas, oblongo-cilíndricas, obovoideas o subglobosas fueron citadas para el género por Harley et al. (2004), encontrándose también las piriformes (*C. darwinii*) y obclavado-subuladas (*C. bolivianum* subsp. *tarijense* y *C. odorum*). El ápice y la base de estos frutos también contribuyen para la diferenciación específica (Martín Mosquero et al. 2004); así, en general el ápice es redondeado destacándose *C. bolivianum* subsp. *tarijense* y *C. odorum* por presentar el ápice alargado a muy alargado y curvo; en cuanto a la base, es propia para cada especie salvo en *C. odorum* y *C. gilliesii* que comparten la característica de ser turbinada.

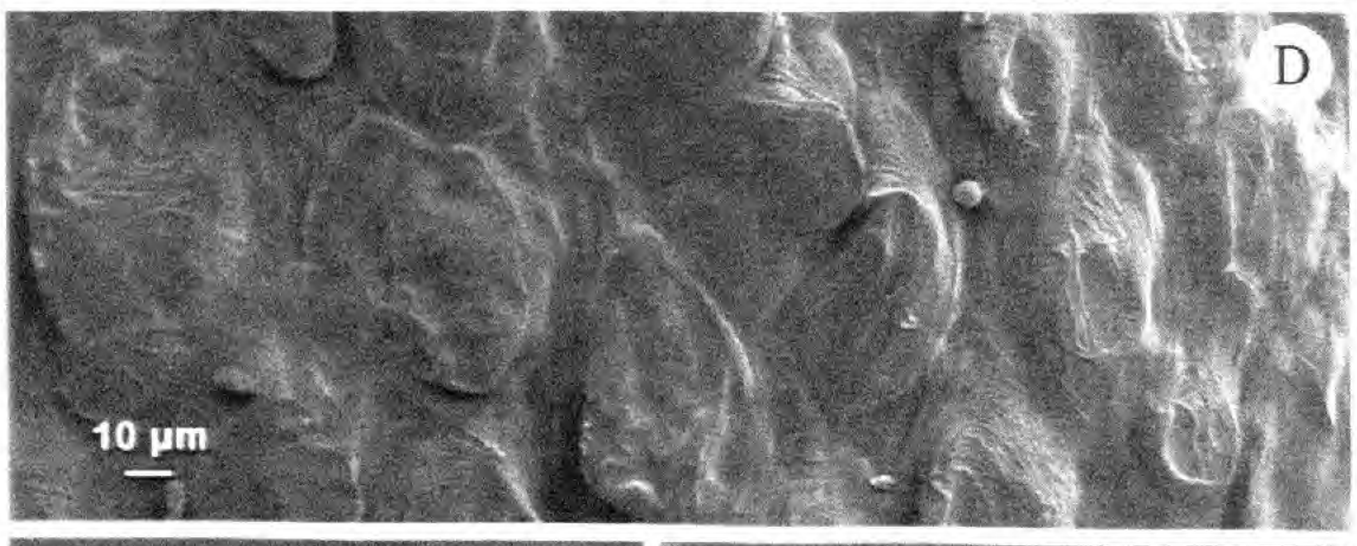
Según la clasificación de Moon et al. (2009), solo *C. bolivianum* subsp. *tarijense* presenta frutos grandes (> 2 mm, ápice incluido), mientras que en el resto de las especies son pequeños (< 2 mm) tal como lo reportado para *C. vulgare* y *C. nepeta* (Husain et al. 1990; Martín Mosquero et al. 2004; Moon et al. 2009).

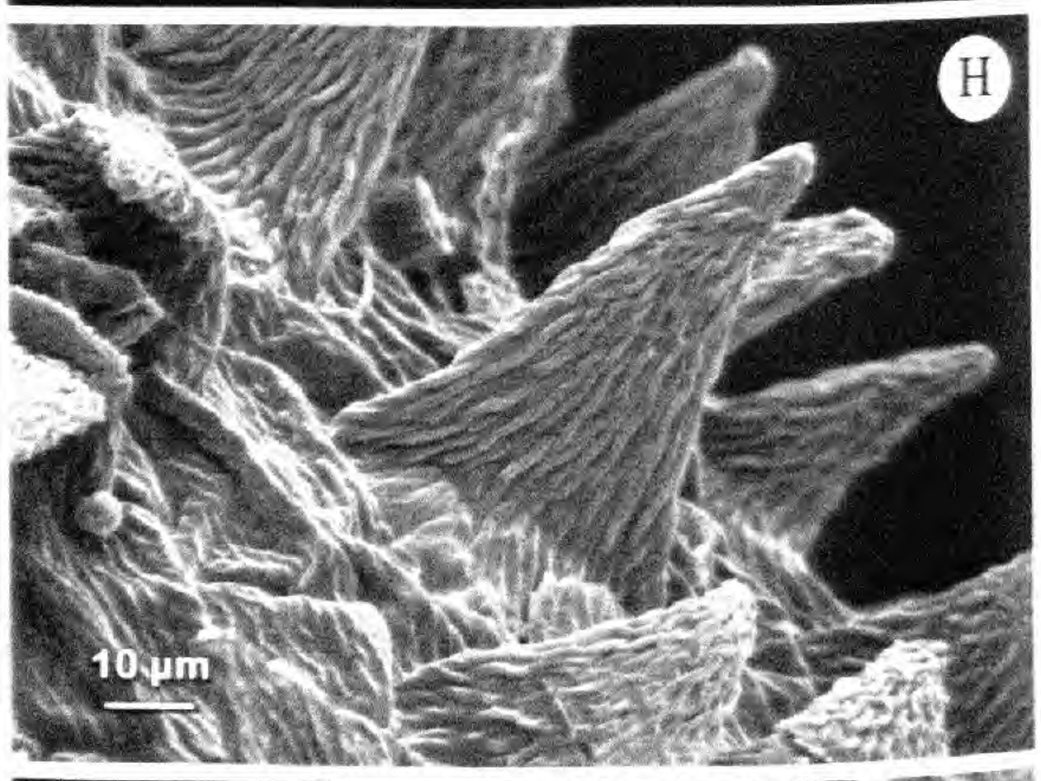


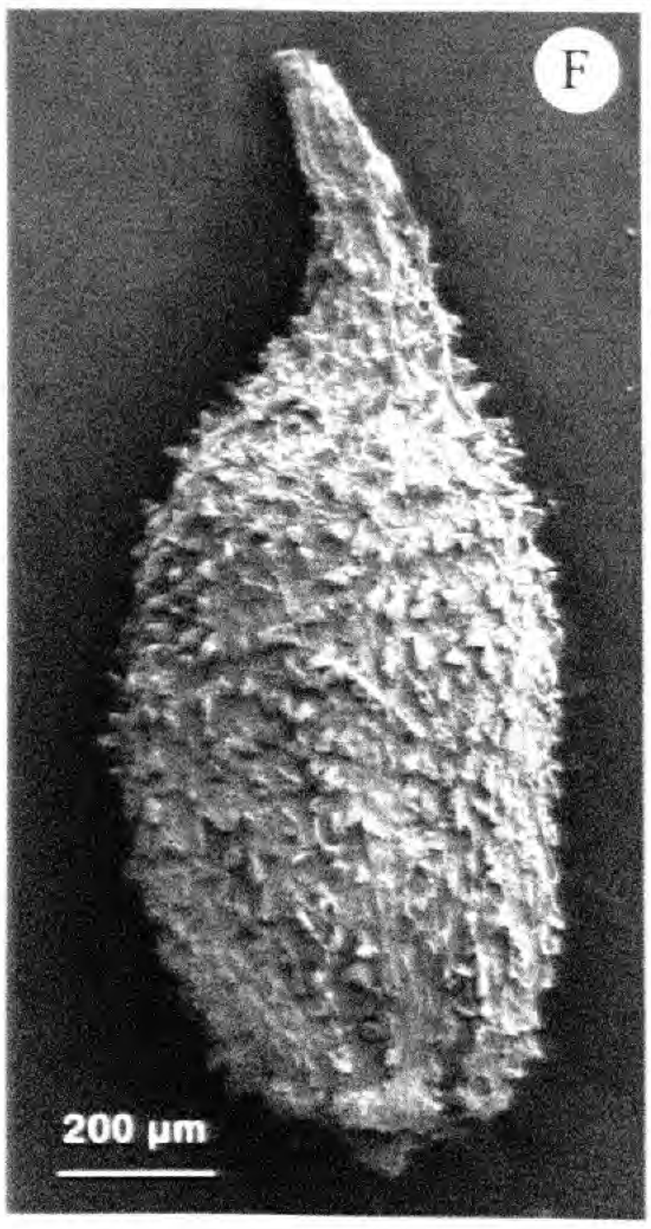


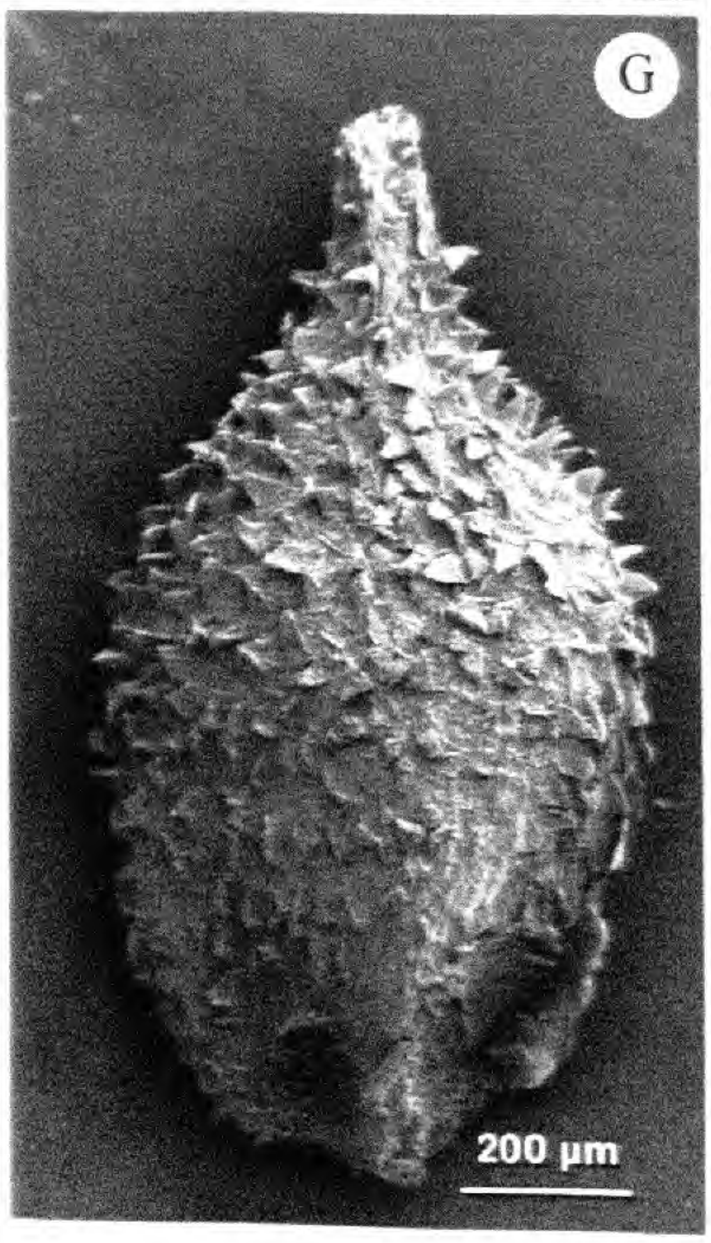












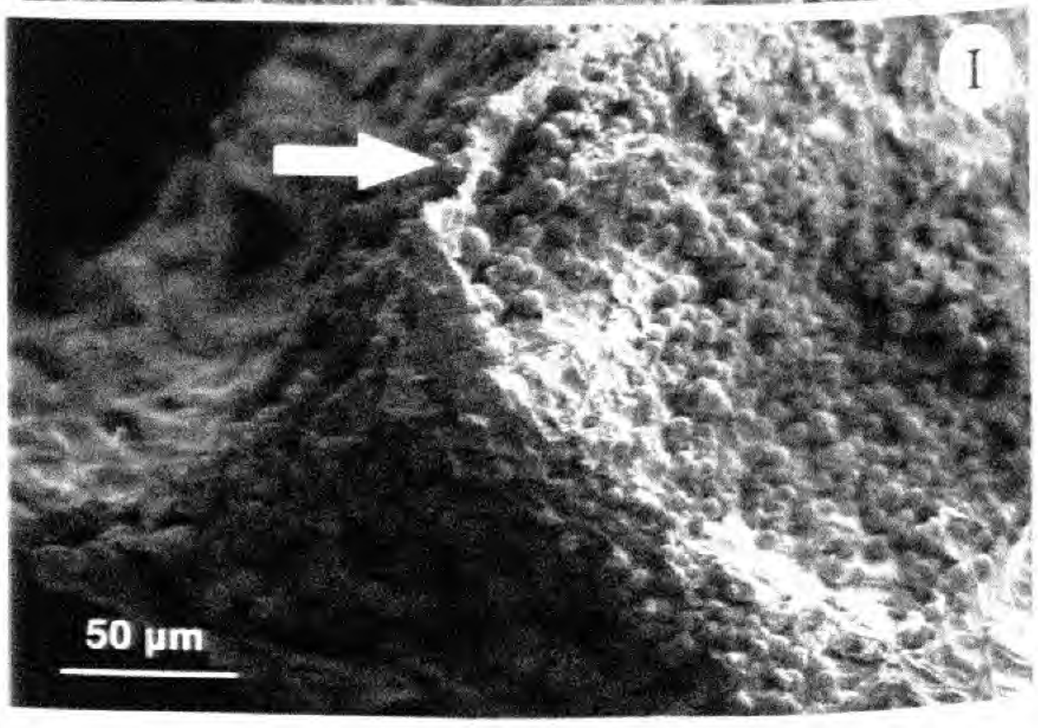


Fig. 4. Microfotografías con MEB. **A–E** *Clinopodium gilliesii*. **A.** Vista cara dorsal; **B.** Vista cara ventral; **C.** Detalle de los tricomas y su ornamentación del ápice del fruto; **D.** Detalle de ornamentación de la superficie en la zona media e inferior; **E.** Vista zona hilar. **F–I** *C. odorum*. **F.** Vista cara dorsal; **G.** Vista cara ventral; **H.** Detalle de ornamentación de la superficie; **I.** Vista zona hilar. Con flecha se muestra el hilo cárpico. (A–E de *CS 1418*. F–I de *CS 1417*).

La presencia o ausencia de tricomas, su posición en los frutos y el número de células aportan caracteres diagnósticos a nivel específico. La variación va desde frutos glabros (*C. darwinii* y *C. brownei*), apicalmente pubescentes (*C. bolivianum* subsp. *tarijense* y *C. gilliesii*) a íntegramente cubiertos por tricomas (*C. odorum*). En cuanto al numero de celulas, son pluricelulares en *C. bolivianum* subsp. *tarijense* y unicelulares en las otras dos.

Tabla 1. Caracteres diferenciales exomorfológicos, anatómicos y mixocarpia en especies de *Clinopodium*.

	C. bolivianum subsp. *tarijense*	*C. brownei*	*C. darwinii*	*C. gilliesii*	*C. odorum*
Forma	Largamente obclavado-subulada, ápice curvo, base obtusa (Fig. 1 A, B)	Elipsoidea, ápice y base redondeadas (Fig. 1 G, H)	Piriforme, ápice redondeado, base truncada (Fig. 2 A, B)	Obovoidea, ápice obtuso a redondeado, base turbinada (Fig. 4 A, B)	Obclavado-subulada, ápice curvo, base turbinada (Fig. 4 F, G)
Tamaño (mm)	2–2,4 × 0,4–0,5	1–1,2 × 0,7–0,8	1,6–1,8 × 0,9–1	1,1–1,3 × 0,5–0,6	1,4–1,5 × 0,5–0,7
Simetría	Asimétricas (Fig. 1 A, B)	Levemente asimétricas (Fig. 1 G, H)	Levemente asimétricas (Fig. 2 A)	Asimétricas (Fig. 4 A)	Asimétricas (Fig. 4 F, G)
Superficie	Mitad superior con tricomas estriado-acordonados (Fig. 1C). Mitad inferior reticulado-areolado, lisa a levemente estriada (Fig. 1 E)	Reticulado redondeado – radiado (Fig 1 I)	Reticulado redondeado – radiado, con estrías cuticulares concéntricas (Fig. 2 C)	Tuberculada (Fig. 4 A, B) excepto el ápice con tricomas estriado-acordonados (Fig.4 C). Tubérculos con leves estriaciones concéntricas (Fig. 4 D)	Espinulosa (Fig. 4 F, G), con tricomas estriado-acordonados (Fig. 4 H)
Hilo cárpico	Alargado (Fig. 1 D)	Triangular (Fig. 1 H)	Triangular (Fig. 2 D)	Elíptico (Fig. 4 E)	Alargado (Fig. 4 I)
Mixocarpia	Moderadamente fuerte, halo continuo de 0,17–0,3mm (Fig. 2 G)	Moderadamente fuerte, halo continuo de 0,23–0,25mm (Fig. 2 F)	Moderadamente fuerte, halo continuo de 0,12–0,25mm (Fig. 2 E)	Ausente	Ausente
Grosor pericarpo (µm)	25–32,8	88,9–106,2	29,7–45,2	27,4–37,5	59,2–79,9
Epicarpo (µm)	7,8–9,4	12,5–20,3	4,7–7,8	7,8–9,4	14–19
Tricomas	Pluricelulares	–	–	Unicelulares	Unicelulares
Mesocarpo (µm)	14,1–18,7	74,8–84,3	21,9–31,2	16,5–25	42,1–56,2
N° regiones mesocarpo	3	3	2	3	3
Esclereidas (µm)	7,8–9,4	65,5–71,8	17,2–23,4	7,8	15,6–20,3
Endocarpo (µm)	3,1–4,7	1,6	3,1–6,2	3,1	3,1–4,7

en todos los casos, estos tricomas están cubiertos por una gruesa cutícula estriado-acordonada, carácter que no había sido mencionado en la literatura para el género.

La ornamentación presenta diferentes patrones que concuerdan con los descritos por Budanstev & Lobova (1997) para algunos géneros de Nepetoideae y complementan a los mencionados por Moon et al. (2009) para la tribu Mentheae. Así, *C. vulgare* y *C. nepeta*, que poseen superficie reticulada con estructura secundaria estriada (Moon et al. 2009), comparten este carácter con *C. bolivianum* subsp. *tarijense*, *C. brownei* y *C. darwinii*. Estas tres especies se distinguen a su vez por la forma de la superficie reticulada y la estructura secundaria (cfr. Tabla 1), modelos que ya habían sido descritos para especies de *Mentha* (Bonzani et al, 2011). Por su parte, *C. gilliesii* presenta superficie tuberculada y *C. odorum* espinulosa dada por la cobertura total de los tricomas.

El hilo cárpico, ubicado en la base hacia la cara ventral, varía en su forma desde alargado (*C. bolivianum* subsp. *tarijense* y *C. odorum*), elíptico (*C. gilliesii*) a triangular (*C. brownei* y *C. darwinii*). En cambio, la región perihilar es homogénea en todas las especies, con depósitos de ceras cristaloide esféricos similares a lo mencionado por Martín Mosquero et al. (2004) así como a los de algunas especies de otros géneros de Nepetoideae: *Mentha* L. (Bonzani et al. 2011), *Hedeoma* Pers., *Minthostachys* (Benth.) Spach, *Lepechinia* Willd. (Scandaliaris & Barboza 2011, 2012), *Hyptis* Jacq. (obs. pers.).

Mixocarpia

Según la literatura, los frutos de las especies de *Clinopodium* hasta ahora estudiadas no producen mucílagos (Duletić-Laušević & Marin 1999; Moon et al. 2009). Pudimos comprobar que este fenómeno está presente en el género pero no es constante para todas las especies nativas de Argentina (cfr. Tabla 1). Este carácter, que resulta novedoso para *Clinopodium*, se comporta de acuerdo a lo reportado para otros géneros (Harley 1985; Ryding 1992, 2001), en lo que concierne a su presencia/ausencia y al tipo de reacción producida; en este último caso, las especies mixocárpicas analizadas presentan mucílago expuesto con reacción moderadamente fuerte.

Ryding (1992), para la tribu Ocimeae (Nepetoideae), concluye que tendencias evolutivas hacia la reducción de la mixocarpia se han observado en especies que crecen en ambientes húmedos, o que tienen frutos grandes o en aquéllas que poseen frutos con glándulas o con pelos (salvo que éstos solo estén presentes en el ápice). Si relacionamos estas afirmaciones con las especies argentinas de *Clinopodium* (tribu Mentheae, Nepetoideae), se observaron distintas situaciones: en las especies de zonas húmedas, *C. browneii* (litoral argentino) y *C. bolivianum* subsp. *tarijense* (selva tucumano-boliviana), ambas con mixocarpia moderadamente fuerte, no responden a lo supuesto por Ryding (1992). En cuanto a las especies de zonas semiáridas, *Clinopodium gilliesii* (Argentina hasta Perú), no mixocárpica, se contrapone a lo esperado por este autor ya que según el hábitat y la presencia apical de pelos en el fruto tendría que ser mixocárpica. En cambio, *C. odorum* (zona semiárida del centro y norte de Argentina) y *C. darwinii* (estepa patagónica), se ajustan a las afirmaciones de Ryding (1992) siendo esta última una especie mixocárpica típica de ese ambiente en tanto que la primera es no mixocárpica, presentando sus frutos cubiertos completamente por pelos, los que, según Ryding (1992, 2001) cumplen la función de anclaje reemplazando al mucílago.

Anatomía

A pesar de que los caracteres histológicos del pericarpo han demostrado ser de importancia taxonómica tanto a nivel de familia como en las categorías inferiores (Cantino et al. 1992; Ryding 1994, 1995), para *Clinopodium* la información sobre la histología de los frutos es por demás escasa. Solo Martín Mosquero et al. (2004) han descripto en detalle la carpología de *C. vulgare* subsp. *arundanum* (Boiss.) Nyman y *C. nepeta* (L.) Kuntze (sub nom. *Calamintha nepeta* subsp. *nepeta*) en tanto que Wojciechowska (1966), Ryding (1995, 2010) y Duletić-Laušević and Marin (1999) mostraron resultados mayormente cuantitativos sobre cada región del pericarpo de otras 6 especies, entre las que se incluye a *C. bolivianum*. Estos datos tan fragmentarios impiden hacer una evaluación sobre su incidencia taxonómica.

Epicarpo.—La estructura del pericarpo de las especies analizadas en este trabajo pusieron en evidencia dos patrones anatómicos en el epicarpo que se asocian a la producción de mucílagos. Así, en las especies con mixocarpia, el epicarpo unistrato consta de células mucilaginosas grandes, alargadas tangencialmente, en

transcorte, que se entremezclan con otras no mucilaginosas alargadas radialmente, como ocurre en *C. bolivianum* subsp. *tarijense* (cfr. Fig. 3 B), *C. browneii* y *C. darwinii*.

Al igual que en otros géneros con especies mixocárpicas de las Menthinae, p.e. *Conradina* A. Gray, *Dicerandra* Benth., *Hedeoma* Pers., *Pycnanthemum* Michx. y *Rhabdocaulon* Epling (Ryding 1995), las especies de *Clinopodium* coinciden con el tipo 1 del ordenamiento de células mucilaginosas y no mucilaginosas propuesto por Ryding (1995), es decir células mucilaginosas solitarias o en pequeños grupos, separadas por pequeñas células no mucilaginosas.

El segundo patrón observado en *Clinopodium* (*C. odorum*, Fig. 3 D, y *C. gilliesii*) corresponde a un epicarpo con células que no producen mucílago las que, a diferencia de las no mucilaginosas del patrón anterior, son alargadas tangencialmente en transcorte. Estas características celulares son similares a las observadas en *C. vulgare* por Wojciechowska (1966). El engrosamiento de las paredes celulares en las especies aquí estudiadas es uniformemente delgado, lo que difiere de lo reportado por Martín Mosquero et al. (2004) para *C. vulgare* subsp. *arundanum*, quien describió e ilustró a las células no mucilagionosas con paredes radiales engrosadas. Por su parte, *C. nepeta* está reportada como especie no mucilaginosa (Moon et al. 2009) a la par que Martín Mosquero et al. (2004) describe la estructura de su epicarpo acorde a la ausencia de mixocarpia. Por nuestra parte, pudimos comprobar que esta especie, además de secretar mucílago, posee las características del epicarpo del patrón 1 señalado más arriba.

La estructura del epicarpo en las especies no mucilaginosas de Nepetoideae es variable: así, el epicarpo puede estar integrado por: esclereidas exclusivamente (p.e. *Lepechinia*, Ryding 1995, 2010), sólo por células con todas sus paredes delgadas (p.e. *Clinopodium*, este trabajo), o todas engrosadas (p.e. *Hyptis*, obs. pers.), o sólo por células con paredes tangenciales delgadas y radiales engrosadas (p.e. *C. vulgare* subsp. *arundanum*, Martín Mosquero et al. 2004), o paredes tangenciales engrosadas y radiales delgadas (p.e. *Lophanthus* Adans., *Hymenocrater* Fisch. & C.A. Mey., *Meehania* Britton ex Small & Vail, Budanstev & Lobova 1997); por último, las células del epicarpo pueden alternar con tricomas (*Clinopodium* spp., este trabajo).

Mesocarpo.—Acorde a Ryding (1995, 2010), el número de capas del mesocarpo de las Nepetoideae varía desde 2–15 (25), incluyendo la capa de esclereidas. En *Clinopodium*, el mesocarpo consta de 3–4 capas que se diferencian claramente en 3 regiones, por la forma y tipo de células (aplanadas o isodiamétricas, parenquimáticas o esclerenquimáticas) y su coloración (intensamente teñidas o incoloras). Esta organización es similar a lo esquematizado por Ryding (2010) para Mentheae. Sin embargo, en *Clinopodium* la región externa es distinta según se trate de especies mixocárpicas o no; en las primeras, las células son siempre aplanadas de bordes difusos e intensamente teñidas, a diferencia de lo que observa Martín Mosquero et al. (2004) para *C. nepeta*, mientras que en las no mixocárpicas las células son más o menos redondeadas e incoloras tal como se indica para *C. vulgare* subsp. *arundanum* (Martín Mosquero et al. 2004). Por su parte, la región media, de células isodiamétricas o aplanadas, es siempre incolora en las especies argentinas a diferencia de lo observado para las dos especies anteriores por Martín Mosquero et al. (2004). Por último, el grosor de la capa más interna, que corresponde a las esclereidas en empalizada, es el carácter más variable incluso dentro de los *Clinopodium* estudiados, pudiendo ser más o menos isodiamétricas (*C. bolivianum* subsp. *tarijense*) o alargadas radialmente (*C. brownei*, *C. darwinii*, *C. gilliesii*, *C. odorum*). La presencia y número de cristales en las esclereidas es también un rasgo a ser considerado. Así, *C. vulgare* subsp. *arundanum* se destaca por el elevado número de cristales en el lumen (hasta 12) mientras que *C. nepeta* posee sólo uno (Martín Mosquero et al. 2004) en contraposición a las especies nativas de Argentina aquí analizadas que carecen de cristales. Al respecto, Ryding (1995) advirtió la importancia taxonómica de este carácter al señalar los distintos tipos y cantidad de cristales que pueden aparecer en Lamioideae y Nepetoideae.

Endocarpo.—Al igual que la generalidad propuesta por Ryding (1995, 2010) para Lamiaceae, el endocarpo es unistrato de células parenquimáticas. Según este autor, la presencia o ausencia de engrosamiento en las paredes celulares tiene importancia taxonómica. Por nuestra parte, hemos observado que la mayoría de las especies analizadas poseen paredes celulares con engrosamientos de tipo escalariforme coincidiendo con Martín Mosquero et al. (2004) quienes lo señalan para *C. nepeta* pero no lo reportan para *C. vulgare* subsp. *arundanum*.

Consideraciones taxonómicas

Bräuchler et al. (2010) analizaron ca. 50% de las especies de *Clinopodium* mediante datos de ADN nuclear (ITS) y cloroplastidial (*trnK/trnL-F*), definiendo numerosos subgrupos monofiléticos dentro de este género s. l.

En el grupo Kurzamra, con buen soporte en el análisis cloroplastidial (cpDNA), estos autores ubicaron a *Clinopodium darwinii* junto a *Kurzamra pulchella* (Clos) Kuntze y otras dos especies: *Clinopodium multiflorum* (Ruiz & Pav.) Kuntze y *Cuminia eriantha* (Benth.) Benth., estas últimas endémicas del centro-sur de Chile. Desde el punto de vista carpológico, *C. darwinii* y *K. pulchella* son mixocárpicas y comparten similar estructura del pericarpo (obs. pers.); estos caracteres se suman al hábito de matas en forma de cojín propio de zonas semi-desérticas, si bien *C. darwinii* es de la estepa patagónica a diferencia de *K. pulchella* que vive a grandes altitudes (3500–4100 m). En cuanto a las diferencias, estas dos entidades se distinguen no solamente por su cáliz (oscuramente bilabiado, tubuloso, lóbulos netamente no subulados y no plumosos en *C. darwinii* vs. actinomorfo, tubo muy corto y cilíndrico-infundibuliforme, lóbulos largamente subulados y plumosos en *K. pulchella*) sino también por la forma (piriforme vs. oblongo ovado) y tamaño de los frutos (1,8–1,9 mm vs. 1,5 mm). Un rasgo destacable diferencial son los cristales en el interior de las esclereidas que están presentes en *K. pulchella* (obs. pers.) y totalmente ausente en las especies de *Clinopodium* analizadas.

Clinopodium bolivianum aparece agrupado con especies de *Minthostachys* en el grupo Minthostachys, tanto en el análisis cpDNA como en ITS (Bräuchler et al. 2010); estos resultados agrupan a *C. bolivianum* junto a *C. gilliesii*, *C. axillare* (Rusby) Harley y *C. vanum* (Epling) Harley & A. Granda, los que, morfológicamente, son similares por la forma del cáliz (campanulado o cilíndrico). Por su parte, Schmidt-Lebuhn (2008) agrupa a estas mismas especies junto a otras, bajo el grupo parafilético Xenopoma en el árbol obtenido del análisis cladístico morfológico y también en el logrado por análisis molecular. En cuanto a las especies argentinas, *C. bolivianum* y *C. gilliesii*, emparentadas según estas propuestas, poseen frutos similares por compartir tricomas solo en su ápice diferenciándose por la forma, tamaño, reacción mucilaginosa y estructura del pericarpo (cfr. Tabla 1). Se carecen de datos carpológicos para las otras especies de *Clinopodium* del grupo Minthostachys.

Clinopodium brownei fue solamente incluido en el análisis molecular de Bräuchler et al. (2010) donde aparece en una posición irresuelta dentro de los *Clinopodium* del Nuevo Mundo. Esta especie no presenta particularidades destacables en su carpología siendo similar en la estructura del pericarpio y en la reacción mucilaginosa a *C. bolivianum* y *C. darwinii*.

Por último, *Clinopodium odorum* al momento no ha sido incluido en ningún análisis filogenético.

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BOOK REVIEW

LORRAINE G. BONNEY. 2011. **The Big Thicket Guidebook: Exploring the Backroads and History of Southeast Texas.** (ISBN: 978-1-5744-1318-2, cloth hbk). Big Thicket Association, University of North Texas Press, 1155 Union Circle #311336, Denton, Texas 76203-5017, U.S.A. (**Orders:** www.unt.edu/untpress, www.tamupresscom, 1-800-826-8911). $29.95, 848 pp., 100 illus., 16 maps, bib., index, 6" × 9".

Whether you are the "Quick, Honey. Grab the kids and suitcases and let's hit the open road!" or the "I'll just curl up in my favorite easy chair and read without actually having to go anywhere" type, you will undoubtedly enjoy this large, carefully researched, informative, colorful, and delightfully humorous book. Canadian by birth, Lorraine was married to the late Houston attorney Orrin H. Bonney. They were co-authors, and after his death Lorraine finished two books, *The Grand Controversy: History of Climbing in the Tetons in 1934* and *Wyoming Mountain Ranges*.

This volume is actually Number 6 in the Temple Big Thicket Series, published by the Big Thicket Association (University of Texas Press, Denton). It contains a wealth of background information, accompanied by current maps, very specific instructions, and delightful tales of the people who lived there—and still live there—throughout the known history of the area. Be sure to read the General Introduction (pp. x–xiv) for a quick assessment of what you are about to enjoy.

If you are planning to visit the Big Thicket, by all means, take this volume with you! If you're flying to Texas and renting a car to visit the area—or for that matter, if you live in Texas but have a passel of kids and luggage—you might hesitate because of the book's size. Nevertheless, you will benefit greatly by having it with you. Part I, entitled "Some East Texas History," provides a quick overview; Part II, "Some Southeast Texas Towns," provides a great and often humorous account of the colorful towns and their equally colorful inhabitants along the way; and Part III, "Roadside History of Southeast Texas," provides very, very specific—and current!—road information about getting to all the colorful places. It identifies 15 tours, but it also includes specific sections in the larger areas. (How specific? Well, as an example, Tour 6 also has a Tour 6A, Tour 6B, and Tour 6C!) Part III starts on p. 199 and continues to p. 787. And it is all both fun and fascinating, as well as telling you specifically how to get to your intended destinations.

In the General Introduction, Professor Emeritus Pete A.Y. Gunter refers to the late comedian Johnny Carson's famous claim that there was only one fruitcake in the entire world; it just got passed from one family to another. He continues:

> "In one respect Lorraine Bonney's *The Big Thicket Guidebook* is simple. It is a travelogue, guiding the reader through the Big Thicket. But, like the 'Thicket' itself, her writing is and has to be a tangle of folklore and topography, of geology and history, of biology and personality. It is an unlikely compendium of local hearsay, careful archival research, wild improbable stories and data dug out of courthouse records. It is indeed—the texture of a fruitcake: uneven, in part sour, in part sweet, at times fun, at times hard to digest, and extremely rich (in details)."

Whether you are an active and happy traveler or an armchair reader, you will probably be delighted to keep this book handy, available for browsing or active trip-planning, and/or just plain enjoyable reading.

—*Helen Jeude, Volunteer & Assistant Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

SYSTEMATICS, PHYLOGENY, AND BIOGEOGRAPHY OF *CHAETOLEPIS* (MELASTOMATACEAE)

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ABSTRACT

Cladistic analyses based on morphology were conducted to test for monophyly, estimate the phylogenetic relationships among the taxa of *Chaetolepis*, and generate the first comprehensive taxonomic revision of the genus. Prior to this study the genus had included species from Andean South America, the Guayana Highlands, Costa Rica, Cuba, and tropical West Africa. As traditionally delimited, *Chaetolepis* is not monophyletic because the Cuban species, *C. cubensis*, is more closely related to outgroup species in the genus *Tibouchina*. Based on discordant morphological characters such as foliar trichome details and seed morphology, *C. cubensis* is here treated as a *Tibouchina*, the genus to which it had been transferred by M. Gómez in 1894. *Chaetolepis* is treated as a monophyletic genus of 11 species distinguished by 4-merous flowers, isomorphic stamens that lack prominent pedoconnectives and appendages, apically setose 4-locular ovary, capsular fruits, and cochleate seeds. *Chaetolepis alpina* var. *latifolia* is relegated to synonymy of *C. alpina* because it lacks consistent distinguishing characters, and *C. thymifolia* is synonymized under *C. anisandra*. The West African monotypic genus, *Nerophila gentianoides*, is tentatively shown to be congeneric with the Central and South American species of *Chaetolepis* based on morphology. If molecular data confirms this disposition of *N. gentianoides* by Jacques-Félix, it will become the only genus of Melastomataceae with a trans-Atlantic distribution. A biogeographical analysis based on the phylogenetic results suggests that *Chaetolepis* originated in the Colombian Andes and possibly the Sierra Nevada de Santa Marta, with independent dispersal events to Costa Rica, Venezuela, and tropical West Africa.

RESUMEN

Se llevaron a cabo Análisis cladísticos basados enmorfológía para probar la monofilia, estimar las relaciones filogenéticas entre los taxones de *Chaetolepis*, y generar la primera revisión taxonómica completa del género. Antes de este estudio el género había incluido las especies de los Andes de América del Sur, las tierras altas de Guayana, Costa Rica, Cuba, y tropicales de África occidental. Como se ha delimitado tradicionalmente, *Chaetolepis* no es monofilético ya que la especie cubana, *C. cubensis*, está más estrechamente relacionada con la especies del grupo externo del género *Tibouchina*. Se trata aquí en base a caracteres morfológicos discordantes como los detalles de tricomas foliares y morfología de la semillas como una *Tibouchina*, *C. cubensis*, el género al que había sido trasladado por M. Gómez en 1894. *Chaetolepis* se trata como un género monofilético de 11 especies que se distinguen por sus flores con 4 pétalos, estambres isomorfos que carecen de pedoconnectivos prominentes y apéndices, los ovarios apicalmente setosos 4-loculares, frutos capsulares y semillas cocleadas. *Chaetolepis alpina* var. *latifolia* se sinonimiza a *C. alpina* porque carece de caracteres distintivos constantes, y *C. thymifolia* se sinonimia a *C. anisandra*. El género monotípico de África Occidental, *Nerophila gentianoides*, está tentativamente demostrado ser congenérico con las especies centro y sudamericanas de *Chaetolepis* basado en la morfología. Si los datos moleculares confirman esta disposición de *N. gentianoides* por Jacques-Félix, será el único género de Melastomataceae con una distribución transatlántica. Un análisis biogeográfico basado en los resultados filogenéticos sugiere que *Chaetolepis* se originó en los Andes colombianos y, posiblemente, la Sierra Nevada de Santa Marta con eventos de dispersión independientes a Costa Rica, Venezuela, y África occidental tropical.

INTRODUCTION

Chaetolepis Miq. (Melastomataceae) is a small mostly neotropical genus of montane shrubs and subshrubs (rarely annuals). As interpreted here, it consists of 11 species that are readily characterized by 4-merous, diplostemonous flowers, isomorphic mostly inappendiculate stamens that lack well-developed pedoconnectives, 4-locular, apically setose ovaries, and cochleate seeds with a testa that consists mostly of compressed/flattened interdigitating cells. The genus, as it has been circumscribed in the past, has included species of Andean South America, the Guayana Highlands, southern Central America, and Cuba. Recently, the monotypic genus *Nerophila* Naudin, from west tropical Africa was transferred to *Chaetolepis* (Jacques-Félix 1995). No previous study has attempted to evaluate *Chaetolepis* or *Nerophila*. Because the monophyly of the geographically disparate assemblage of taxa referred to *Chaetolepis* had never been evaluated, it seemed ripe for testing.

The primary goals of this study were to determine if *Chaetolepis* is monophyletic, assess the phylogenetic relationships of the constituent species based on morphology, and evaluate character evolution by using cladistic techniques. A taxonomic revision is provided that includes detailed descriptions of all recognized taxa, scanning electron microscope images of seeds for selected species, a summary of known chromosome numbers, information on habitat and geographic distributions, flowering phenology, distribution maps, illustrations of all recognized species, citations of specimens examined, and a list of excluded taxa. This was supplemented by limited field study of four species in Costa Rica, Colombia, and Venezuela.

Tribal and Generic Affinities.—*Chaetolepis* belongs to the tribe Melastomeae, the core members of which are characterized by cochleate seeds with a testa that is tuberculate or papillate, a crown of trichomes or appendages on the ovary apex, and the presence of staminal pedoconnectives (Renner and Meyer 2001; Freire-Fierro 2002; Michelangeli et al. 2013). Based on overall morphological similarities, Wurdack (1973) hypothesized that *Chaetolepis* is most closely related to *Tibouchina* Aubl. No cladistic analyses or molecular data, however, had been used to assess the possible sister relationships of *Chaetolepis*. Other neotropical relatives of *Chaetolepis* include *Aciotis* D. Don, *Arthrostemma* Pav. ex D. Don, *Heterocentron* Hook & Arn., *Microlicia* D. Don, *Microlepis* (DC.) Miq., *Monochaetum* (DC.) Naudin, *Nepsera* Naudin, *Pterolepis* (DC.) Miq., and *Rhexia* L. based on a study using *ndhF* and *rpl16* cpDNA sequences of 24 members of Melastomeae and outgroups (Renner and Meyer 2001). Based on an expanded molecular sampling using DNA sequence data, *Bucquetia* DC., *Castratella* Naudin, and *Monochaetum* are now considered the closest sister taxa of *Chaetolepis* (Penneys et al. 2010; Michelangeli et al. 2013). Like *Chaetolepis*, the majority of species in these genera are also restricted to higher elevation montane environments in the Andes of northwestern South America and all have tetramerous flowers, an apically setulose ovary that is four locular and free from the hypanthium, and capsular fruits.

Comparative Morphology (Characters of Taxonomic Value).—The species of *Chaetolepis* are easily distinguished from each other by characters involving the indument, anther connective, seed surface, petal coloration, and petal margin. The indument found on leaves, internodes, nodes, and floral organs includes eglandular trichomes, glandular trichomes, barbellate/dendritic trichomes, and scales. The distribution of the indument on the vegetative and floral structures varies greatly. It ranges from absent to densely covering the surfaces of vegetative and floral organs. The anther connective prolongation ranges from absent to minutely prolonged (<1mm). It can also be unappendaged, minutely bilobed (<1mm) on the ventral side of the connective, or with a minute dorsal appendage. The seed surface is prevailingly smooth with compressed/flattened interdigitating cells or with elongate somewhat convex interdigitating cells. The petals vary in color from yellow to pink or magenta and their margins are either glabrous or ciliate.

Taxonomic History.—*Chaetolepis* has been treated as a distinct genus since Miquel (1840) characterized the group. Since then several species have been variously treated in monographic (Cogniaux 1891) and regional floristic studies (Standley 1938; Uribe-U. 1972; Wurdack 1973; Almeda 2001). Over the past 80 years some of the species have been described in geographical accounts of the genus and some authors have commented on the placement of *Chaetolepis* species that had been described in other genera (Standley 1938; Wurdack 1973; León and Alain 1974; Martins 1989). Prior to the current study, *Chaetolepis* was believed to comprise 13 species and three varieties. Because all previous studies were largely regional in nature, no attempt was made to identify synapomorphies and only cursory attention was given to the importance and/or variation of certain vegetative and reproductive characters. In Cogniaux's (1891) monograph of Melastomataceae, for example, some of the characters used to characterize *Chaetolepis* included 4-merous flowers; ovate to obovate petals varying in color from rose to purple; 4-locular ovaries with a setose apex; minimally prolonged unappendaged connectives; and ovoid cochleate seeds with smooth surfaces. Almeda's (2001) more recent generic description of a smaller sampling of species is similar but he noted that the petals range from yellow, magenta, to purple and the seed surface appears "smooth or finely and diminutively muriculate." No prior work mentioned any sculptural details of the seed testa because no SEM studies had been attempted. This lack of consistency and detail relating to the seed and other structures may have led to the placement of unrelated species in *Chaetolepis*, perhaps biased by the four-merous flowers and greatly reduced pedoconnective. Furthermore, some

doubt about the monophyly of the genus has persisted because no cladistic analysis of the group has ever been undertaken to evaluate character states and their evolution.

MATERIALS AND METHODS

I. Cladistic and Biogeographic Analyses

Ingroup.—All sixteen taxa thought to comprise *Chaetolepis* form the ingroup for this study. *Chaetolepis alpina* var. *alpina*, *C. alpina* var. *latifolia*, *C. anisandra*, *C. cubensis*, *C. cufodontisii*, *C. gentianoides*, *C. lindeniana*, *C. loricarella*, *C. microphylla*, *C. perijensis* var. *perijensis*, *C. perijensis* var. *glandulosa*, *C. phelpsiae* var. *phelpsiae*, *C. phelpsiae* var. *chimantensis*, *C. santamartensis*, *C sessilis*, and *C. thymifolia*.

Outgroup.—To assess the monophyly of *Chaetolepis*, seven species among the genera *Tibouchina*, *Microlicia*, and *Monochaetum* were used as the outgroup. The exemplars used were *T. gleasoniana* Wurdack, *T. narinoensis* Wurdack, *T. wurdackii* Almeda and Todzia, *Microlicia canastrensis* Naudin, *M. obtusifolia* Cogn. ex R. Romero, *Monochaetum amabile* Almeda, and *M. compactum* Almeda. *Tibouchina* was chosen as part of the outgroup because Wurdack (1973) hypothesized that it likely shares a most recent common ancestor with *Chaetolepis* based on many shared characteristics, such as perigynous flowers, campanulate or urceolate hypanthia, superior ovaries that are apically pubescent, capsular fruits, and cochleate seeds. In addition, *T. gleasoniana*, *T. narinoensis*, and *T. wurdackii* were chosen as part of the outgroup because the tuberculate seed testa and foliar scales (see Todzia and Almeda 1991) are identical to those found in *C. cubensis*. The species of *Microlicia* and *Monochaetum* were chosen as other members of the outgroup because of their close phylogenetic proximity to *Tibouchina* based on molecular studies by Renner and Meyer (2001).

Material Examined.—Over 400 herbarium specimens, including types, were used in the phylogenetic analysis and taxonomic revision. Specimens from the following herbaria with significant holdings of Central and South American Melastomataceae were borrowed or studied on site: BM, BR, CAS, COL, DS, DUKE, F, FMB, G, GH, HECASA, K, M, MO, NY, P, US, and UTMC (acronyms according to Thiers 2012). Internet images of type specimens (JSTOR Plant Science) were examined for those taxa that were not readily available on loan.

Characters.—Forty-one vegetative and floral characters were used in the analysis (Tables 1 and 2). The type of indument covering both vegetative and floral structures was particularly informative in this study.

Data Analysis.—The software program PAUP* 4.0b10 (Swofford 2002) was used to generate phylogenetic estimates. Maximum parsimony with a branch and bound search was selected to evaluate the data matrix that was generated in Maclade 4.03 (Maddison and Maddison 2000). Two analyses were conducted. Analysis 1 was performed to assess the monophyly of *Chaetolepis* and analysis 2 provided insight into ingroup relationships after the exclusion of one of the species of *Chaetolepis* (C. cubensis) was prompted by the results of the first analysis. The first analysis used 41 morphological characters and 23 taxa. Sixteen species formed the presumed ingroup and seven species from the genera *Tibouchina*, *Monochaetum*, and *Microlica* formed the outgroup. Default options were used to run the analysis. In analysis 2, a backbone constraint was applied that grouped all outgroup members plus *C. cubensis* together because of their unique floral and/or seed characters and grouped all ingroup taxa together. This was done by constructing a tree in MacClade (Maddison & Maddison 2000) with the data matrix, opening the file in PAUP (Swofford 2002), derooting the tree, loading the tree as a backbone constraint in the analysis, and finally enforcing the constraint in the search.

To evaluate the strength of the different clades in the various phylogenies generated, a bootstrap analysis employing a heuristic search was utilized in PAUP. Stepwise-addition branch swapping was employed; otherwise, default options were used.

MacClade was used to infer the evolution of characters among the lineages of *Chaetolepis*. The "trace," "all changes," and "all possible changes" options were chosen.

To gain insight into the historical biogeography of *Chaetolepis*, two analyses were conducted. The first was performed to provide insight into the origin and dispersal patterns of the different taxa within South America, Central America, and Africa. This analysis used Fitch opitimization in MacClade, a data matrix incorporating all *Chaetolepis* taxa, a single area character with four states representing different geographic areas

TABLE 1. Morphological characters and character states used in the phylogenetic analysis of *Chaetolepis*.

1. Hypanthium base (glands): no glands (0); punctate, with depressions (1); sessile glands (2).

2. Hypanthium base (trichomes): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated, slightly to greatly barbellate trichomes (3).

3. Hypanthium base (scales): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally attached without a raised thickening near the point where scale attaches to surface, erose margin (2).

4. Hypanthium apex (glands): no glands (0); punctate, with depressions (1); sessile glands(2).

5. Hypanthium apex (trichomes): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated, slightly to greatly barbellate trichomes (3).

6. Hypanthium apex (scales): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally attached without a raised thickening near the point where scale attaches to surface, erose margin (2).

7. Leaf margin: glabrous (0); ciliate (1).

8. Leaf margin (pattern): crenulate (0); serrulate (1); entire (2).

9. Adaxial leaf surface (glands): no glands (0); punctate, with depressions (1); sessile glands (2).

10. Adaxial leaf surface (trichomes): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated slightly to greatly barbellate trichomes (3); bulla- based trichomes (4).

11. Adaxial leaf surface (scales): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally attached without a raised thickening near the point where scale attaches to surface, erose margin (2); appressed, lanceolate, flattened scales, attached entire length of scale, erose margin (3); appressed, lanceolate, flattened scales, basally attached, entire margin (4); flattened scales adnate for ⅓ to ⅔ their length, distal region of scales free and triangular (5).

12. Abaxial leaf surface (glands between primary veins): no glands (0); punctate, with depressions (1); sessile glands (2).

13. Abaxial leaf surface (trichomes between primary veins): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated slightly to greatly barbellate trichomes (3); variously branched and terete (4).

14. Abaxial leaf surface (scales between primary veins): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally or basally attached without a raised thickening near the point where scale attaches to surface, erose margin (2); appressed, lanceolate, flattened scales, attached entire length of scale, erose margin (3); appressed, lanceolate, flattened scales, basally attached, entire margin (4); flattened scales adnate for ⅓–⅔ their length, distal region of scales free and triangular (5).

15. Abaxial leaf surface (glands on primary veins): no glands (0); punctate, with depressions (1); sessile glands (2).

16. Abaxial leaf surface (trichomes on primary veins): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated slightly to greatly barbellate trichomes (3).

17. Abaxial leaf surface (scales between primary veins): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally or basally attached without a raised thickening near the point where scale attaches to surface, erose margin (2); appressed, lanceolate, flattened scales, attached entire length of scale, erose margin (3); appressed, lanceolate, flattened scales, basally attached, entire margin (4); flattened scales adnate for ⅓–⅔ their length, distal region of scales free and triangular (5).

18. Branch surface internodes (glands): no glands (0); punctate, with depressions (1); sessile glands (2).

19. Branch surface internodes (trichomes): no trichomes (0); smooth eglandular trichomes, sparsely pubescent (1); smooth glandular trichomes, sparsely pubescent (2); smooth eglandular trichomes, moderately to densely pubescent (3); smooth glandular trichomes, moderately to densely pubescent (4); elongated slightly to greatly barbellate trichomes (5).

20. Abaxial leaf surface (scales between primary veins): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally or basally attached without a raised thickening near the point where scale attaches to surface, erose margin (2); appressed, lanceolate, flattened scales, attached entire length of scale, erose margin (3); appressed, lanceolate, flattened scales, basally attached, entire margin (4); flattened scales adnate for ⅓–⅔ their length, distal region of scales free and triangular (5).

21. Branch surface nodes (glands): no glands (0); punctate, with depressions (1); sessile glands (2).

22. Branch surface nodes (trichomes): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated slightly to copiously barbellate trichomes (3).

23. Abaxial leaf surface (scales between primary veins): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally or basally attached without a raised thickening near the point where scale attaches to surface, erose margin (2); appressed, lanceolate, flattened scales, attached entire length of scale, erose margin (3); appressed, lanceolate, flattened scales, basally attached, entire margin (4); flattened scales adnate for ⅓–⅔ their length, distal region of scales free and triangular (5).

24. Intercalycine lobe sinus (trichomes): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated, slightly to greatly barbellate trichomes (3); forked (4); stalked and variously branched trichomes (5).

25. Intercalycine lobe sinus (scales): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally attached without a raised thickening near the point where scale attaches to surface, erose margin (2).

26. Calyx vestiture (glands found on structure except midrib): no glands (0); punctate, with depressions (1); sessile glands (2).

27. Calyx vestiture (trichomes, excluding midrib): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated slightly to copiously barbellate trichomes (3).
28. Calyx vestiture (scales, excluding midrib): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally attached without a raised thickening near the point where scale attaches to surface, erose margin (2).
29. Calyx vestiture (glands found on midrib): no glands (0); punctate, with depressions (1); sessile glands (2).
30. Calyx vestiture (trichomes found on midrib): no trichomes (0); smooth eglandular trichomes (1); smooth glandular trichomes (2); elongated slightly to copiously barbellate trichomes (3).
31. Calyx vestiture (scales found on midrib): no scales (0); appressed, ovate, flattened scales, basally attached with a raised thickening near the point where scale attaches to surface, erose margin (1); appressed, lanceolate flattened scales, proximally attached without a raised thickening near the point where scale attaches to surface, erose margin (2).
32. Androecium: isomorphic (0); dimorphic (1).
33. Connective: not prolonged or minutely prolonged (<1mm) and no appendages (0); minutely prolonged <1mm and with 2 ventral appendages or thickenings <1mm (1); prolonged >1mm and with 2 ventral appendages >1mm (2); prolonged >1mm and with 2 dorsal appendages >1mm (3); not prolonged with dorsal appendage (4).
34. Apical pore orientation: ventral (0); dorsal (1).
35. Ovary apex: glabrous and non-punctate (0);smooth eglandular trichomes (1); barbellate trichomes (2).
36. Seed Shape: cochleate (0); reniform (1).
37. Seed testa: smooth with compact, interdigitating cells (0); smooth with elongate, interdigitating cells (1); tuberculate (2); foveolate (3).
38. Leaf primary veins: mostly 1 (0); mostly 3 (1); mostly 5 (2).
39. Merosity: typically 4 (0); typically 5 (1).
40. Petal margin: glabrous or with a terminal trichome (0); ciliate (1).
41. Petal color: yellow (0); ranging from pink, purple, to magenta (1).

in which they are found (Table 3), and one of the 26 most parsimonious tree topologies generated in PAUP with polytomies resolved arbitrarily. The second analysis was performed to infer how *Chaetolepis* taxa may have migrated within the Andes. This analysis differed from the first analysis only in the number of area states (five) used. In the analysis, all equally most parsimonious reconstructions (MPR's) were examined.

II. Chromosome Cytology

Floral bud material was collected in the field, fixed in modified Carnoy's (Bradley 1948) solution (4 chloroform, 3 ethanol, 1 glacial aceitic acid, v/v/v) for 24 hours, transferred to 70% ethanol and stored under refrigeration until studied. The new chromosome count reported here for *Chaetolepis cufodontisii* was made from acetocarmine smears of pollen mother cells using a Zeiss light microscope with phase contrast and a 100x oil immersion objective. Drawings of meiotic figures were made by camera lucida at a magnification of 2100x. The voucher collection for this new count is marked with an asterisk among specimens cited.

III. Taxonomic Revision

A dissecting microscope was used to measure all vegetative and reproductive characters based on dried herbarium material. Reproductive characters were taken from either one mature open flower in the center of an inflorescence or a solitary flower at the apex of a flowering branch for each specimen examined. Leaf characters were scored from mature branches. To ensure that aberrant characteristics were not being recorded, numerous specimens were examined and those with typical traits were used.

A scanning electron microscope (SEM) was used to study the seed morphology of each *Chaetolepis* species. Seeds were affixed to aluminum stubs with double-stick tape and sputter-coated with gold-palladium alloy. Samples were photographed in the scanning electron microscope laboratory at the California Academy of Sciences using a Leo 1450 BP scanning electron microscope at 20kV. Voucher collection data for the SEM images are provided in the relevant figure legends.

RESULTS

I. Cladistic Analyses

Phylogeny.—In the first cladistic analysis, 22 most parsimonious trees, each 136 steps long, were generated. The consistency index was 0.66 and the retention index was 0.79. In the strict consensus tree (Fig. 1), 11

TABLE 2. Morphological character states for species of *Chaetolepis* and the seven outgroup taxa. Polymorphic states are represented as #/ # (ex-0/1).

Species	Characters																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C. alpina var. *alpina*	2	0	0	2	0	0	1	0	2	0	0	1	0	0	2	1	0	2	0	0
C. alpina var. *latifolia*	2	0	0	2	0	0	1	0	2	0	0	1	0	0	2	1	0	2	0	0
C. anisandra	0	0	0	0	0/1	0	1	0	0	1	0	2	1	0	2	1	0	0	3/4	0
C. cubensis	0	0	2	0	0	2	1	2	0	0	5	0	0	2	0	0	2	0	0	2
C. cufodontisii	2	0	0	2	0	0	0	1	2	0	0	1	0	0	0	1	0	0	0	0
C. gentianoides	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
C. lindeniana	0	3	0	0	3	0	1	2	0	4	0	0	3	0	0	3	0	0	5	0
C. loricarella	0	0	1	0	0	1	1	2	0	0	1	0	0	1/2	0	0	1	0	0	1
C. microphylla	0	0	0	0	0	0	1	2	0	3	0	0	3	0	0	3	0	0	5	0
C. perijensis var. *perijensis*	2	0	0	2	0	0	1	2	2	0	0	1	0	0	1	0	0	2	0	0
C. perijensis var. *glandulosa*	2	2	0	2	2	0	1	2	2	0	0	1	0	0	1	0	0	2	0	0
C. phelpsiae var. *phelpsiae*	0	1	0	0	1	0	1	0	0	1	0	1	1/2	0	0	1/2	0	0	1/2	0
C. phelpsiae var. *chimantensis*	0	0	0	0	1	0	1	0	0	1	0	1	1/2	0	0	1/2	0	0	1/2	0
C. santamartensis	0	3	0	0	0	0	1	2	0	3	0	0	3	0	0	3	0	0	5	0
C. sessilis	2	1	0	2	1	0	0	1	0	0	0	1	0	0	0	0	0	2	0	0
C. thymifolia	0	0	0	0	0/1	0	1	0	0	1	0	2	1	0	0	1	0	0	3/4	0
Tibouchina gleasoniana	0	0	2	0	0	2	1	2	0	4	0	0	4	2	0	0	2	0	0	2
Tibouchina narinoensis	0	0	2	0	0	2	1	2	0	4	0	3	0	4	0	0	4	0	0	2
Tibouchina wurdackii	0	0	2	0	0	2	1	2	0	0	5	0	0	2	0	0	2	0	0	2
Microlicia canastrensis	2	2	0	2	2	0	1	2	2	0	0	0	2	0	2	0	0	2	2	0
Microlicia obtusifolia	1/2	0	0	2	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Monochaetum amabile	0	1	0	0	1	0	1	2	0	1	0	0	1	0	0	1	0	0	1	0
Monochaetum compactum	0	1/2	0	0	1/2	0	1	2	0	3	0	0	1	0	0	1	0	0	3	0

clades have bootstrap (BS) values greater than 50%. Clade A includes all *Chaetolepis* taxa and the outgroups *Monochaetum amabile*, *M. compactum*, *Tibouchina gleasoniana*, *T. narinoensis*, and *T. wurdackii* (BS= 81). Clade B includes all *Chaetolepis* taxa except *C. perijensis* var. *perijensis* and *C. perijensis* var. *glandulosa* and includes the outgroups from the genera *Monochaetum* and *Tibouchina* (BS=71). Clade C consists of all *Chaetolepis* taxa except *C. perijensis* var. *perijensis*, *C. perijensis* var. *glandulosa* and *C. sessilis* and includes the outgroups from the genera *Monochaetum* and *Tibouchina* (BS<50). Clade D consists of all *Chaetolepis* taxa except *C. perijensis* var. *perijensis*, *C. perijensis* var. *glandulosa*, *C. sessilis*, *C. alpina* var. *alpina*, and *C. alpina* var. *latifolia* and includes the outgroups from the genera *Monochaetum* and *Tibouchina* (BS<50). Clade E contains all *Chaetolepis* taxa except *C. perijensis* var. *perijensis*, *C. perijensis* var. *glandulosa*, *C. sessilis*, *C. alpina* var. *alpina*, *C. alpina* var. *latifolia*, and *C. cufodontisii* and includes outgroups from the genera *Monochaetum* and *Tibouchina* (BS=53). Clade F is composed of the taxa *C. cubensis*, *T. gleasoniana*, *T. narinoensis*, *T. wurdackii*, *and C. loricarella* (BS= 94). Clade G includes *C. cubensis*, *T. gleasoniana*, *T. narinoensis*, and *T. wurdackii* (BS=80). Clade H includes *C. gentianoides*, *C. phelpsiae* var. *phelpsiae*, *C. phelpsiae* var. *chimantensis*, and the outgroups *Monochaetum amabile* and *M. compactum* (BS<50). Lastly, clade I consists of *C. lindeniana*, *C. santamartensis*, and *C. microphylla* (BS=63).

In the second cladistic analysis, 26 most parsimonious trees 148 steps long were generated. The consistency index was 0.61 and the retention index was 0.74. In the strict consensus tree (Fig. 2), 12 clades have bootstrap values greater than 50%. Clade A includes all *Chaetolepis* taxa and the outgroups *Monochaetum amabile*, *M. compactum*, *Tibouchina gleasoniana*, *T. narinoensis*, and *T. wurdackii* and is the backbone constraint. Clade B consists of all *Chaetolepis* taxa except for *C. cubensis* and *Monochaetum amabile* and *M. compactum* (BS=73). Clade C includes all *Chaetolepis* taxa except for *C. cubensis* (BS=100). Clade D includes *C. alpina* var. *alpina* and *C. alpina* var. *latifolia*, *C. perijensis* var. *perijensis*, *C. perijensis* var. *glandulosa*, *C. sessilis*, and *C. cufodontisii* (BS=58). Clade E includes *C. anisandra*, *C. thymifolia*, *C. gentianoides*, *C. phelpsiae* var. *phelpsiae*, and *C. phelpsiae* var. *chimantensis* (BS=71). Lastly, clade F, includes *C. lindeniana*, *C. santamartensis*, and *C. microphylla* (BS=70).

In one of 26 most parsimonious trees generated in the second cladistic analysis showing how characters change (Fig. 3), clade A is supported by five ambiguous characters. The characters that support this clade

TABLE 2. (continued) Morphological character states for species of *Chaetolepis* and the seven outgroup taxa. Polymorphic states are represented as #/ # (ex-0/1).

Species	Characters																					
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
C. alpina var. *alpina*	0	1	0	1	0	2	0	0	2	0	0	0	0	1	1	0	0	1	0	0	0
C. alpina var. *latifolia*	0	1	0	1	0	2	0	0	2	0	0	0	0	1	1	0	0	1	0	0	0
C. anisandra	0	1	0	1/4	0	0	0	0	0	1/2	0	0	0	1	1	0	0	1/2	0	0	0
C. cubensis	0	0	2	0	2	0	0	2	0	0	2	0	1	0	0	0	2	1	0	1	1
C. cufodontisii	0	1	0	1	0	2	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0
C. gentianoides	0	1	0	5	0	0	1	0	0	0	0	0	0	1	1	0	1	2	0	0	0
C. lindeniana	0	3	0	3	0	0	3	0	0	3	0	0	4	1	2	0	0	1	0	1	1
C. loricarella	0	0	1	0	1	0	0	1	0	0	1	0	0	1	2	0	0	0	0	1	1
C. microphylla	0	1/3	0	1	0	0	0	0	0	3	0	0	0	0	1	0	0	1	0	0	0
C. perijensis var. *perijensis*	2	0	0	1	0	2	0	0	2	0	0	0	0	1	1	0	0	0	0	0	0
C. perijensis var. *glandulosa*	2	0	0	1	0	2	0	0	2	0	0	0	0	1	1	0	0	0	0	0	0
C. phelpsiae var. *phelpsiae*	0	1	0	4	0	2	1/2	0	0	1/2	0	0	0	1	1	0	0	1/2	0	0	0
C. phelpsiae var. *chimantensis*	0	1	0	4	0	2	1/2	0	0	1/2	0	0	0	1	1	0	0	1/2	0	0	0
C. santamartensis	0	3	0	3	0	0	3	0	0	3	0	0	1	1	1	0	0	2	0	1	1
C. sessilis	0	1	0	4	0	2	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0
C. thymifolia	0	1	0	1/4	0	0	0	0	0	1/2	0	0	0	1	1	0	0	1/2	0	0	0
Tibouchina gleasoniana	0	0	4	0	2	0	0	2	0	0	2	0	2	0	1	0	2	2	1	1	1
Tibouchina narinoensis	0	0	2	0	2	0	0	2	0	0	2	0	2	0	1	0	2	2	1	1	1
Tibouchina wurdackii	0	0	2	0	2	0	0	2	0	0	2	1	2	0	1	0	2	1	1	1	1
Microlicia canastrensis	2	2	0	2	0	2	2	0	2	2	0	1	2	0	0	1	3	1	1	0	1
Microlicia obtusifolia	1	0	0	0	0	2	0	0	2	0	0	1	2	0	0	1	3	1	1	0	1
Monochaetum amabile	0	1	0	1	0	0	1	0	0	1	0	1	3	1	1	0	3	1	0	0	1
Monochaetum compactum	0	3	0	1/2	0	1	1/2	0	0	1/2	0	1	3	1	1	0	3	2	0	0	1

TABLE 3. Taxa with four area character states used in the first Fitch optimization analysis, and five area character states used in the second Fitch optimization analysis. Area character states used in the first analysis are: Eastern Cordillera of the Andes (1), Tepuis of Venezuelan Guayana (2), Costa Rica, Talamanca Cordillera (3), and West Africa, Loma Mountains (4). Area character states used in the second analysis are: Sierra Nevada de Santa Marta (1), Eastern Cordillera of the Andes (2), Tepuis of Venezuelan Guayana (3), Costa Rica, Talamanca Cordillera (4), and West Africa, Loma Mountains (5).

Taxa	Area character states used in first Fitch opitimization analysis	Area character states used in second Fitch opitimization analysis
C. alpina var. *alpina*	1	1&2
C. alpina var. *latifolia*	1	1
C. anisandra	1&2	2&3
C. cufodontisii	3	4
C. gentianoides	4	5
C. lindeniana	1	2
C. loricarella	1	1
C. microphylla	1	2
C. perijensis var. *perijensis*	1	2
C. perijensis var. *glandulosa*	1	2
C. phelpsiae var. *phelpsiae*	2	3
C. phelpsiae var. *chimantensis*	2	3
C. santamartensis	1	2
C. sessilis	1	2
C. thymifolia	1	2

include an androecium that is dimorphic (character 32); a prolonged connective with ventral or dorsal appendages (character 33); a ventral apical pore orientation (character 34); foveolate or tuberculate seed testa (character 37); and five-merous flowers (character 39). Clade B, which is composed of all *Chaetolepis* taxa except for *C. cubensis*, is supported by the same five ambiguous characters. There are 13 characters that support clade

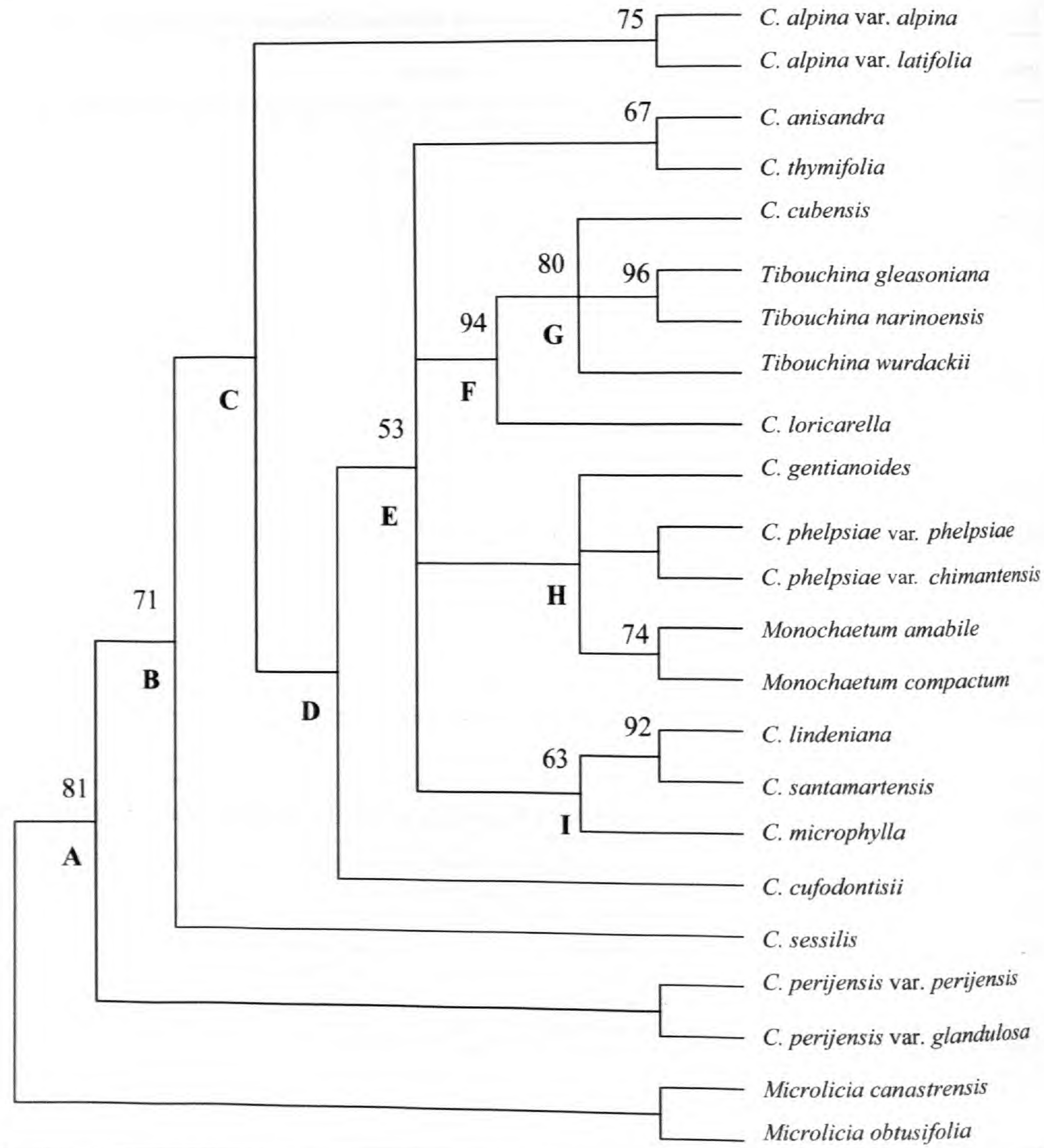


FIG. 1. Strict consensus tree generated from a branch and bound analysis of morphological characters (analysis 1). Bootstrap values greater than 50% are shown above the branches. Letters represent the nodes above them.

C1, of which nine are unique, three are homoplasious and one is ambiguous. The unique characters include appressed, ovate, flattened scales, basally attached with a raised thickening near the point where the scale is attached to the leaf surface and an erose margin on the hypanthium base, hypanthium apex, adaxial leaf surface, abaxial leaf surface primary veins, branch surface internodes, branch surface nodes, intercalycine lobe sinus, calyx vestiture excluding the midrib, and calyx midrib (characters 3, 6, 11, 17, 20, 23, 25, 28, 31 respectively). There are 4 characters that support clade C2, of which three are ambiguous and one is homoplasious (characters 16, 22, 24, and 41). The ambiguous characters are smooth eglandular trichomes, smooth glandular trichomes, or barbellate/dendritic trichomes on the abaxial leaf surface (primary and secondary veins); smooth eglandular trichomes, smooth glandular trichomes, or barbellate trichomes on the branch surface nodes; and

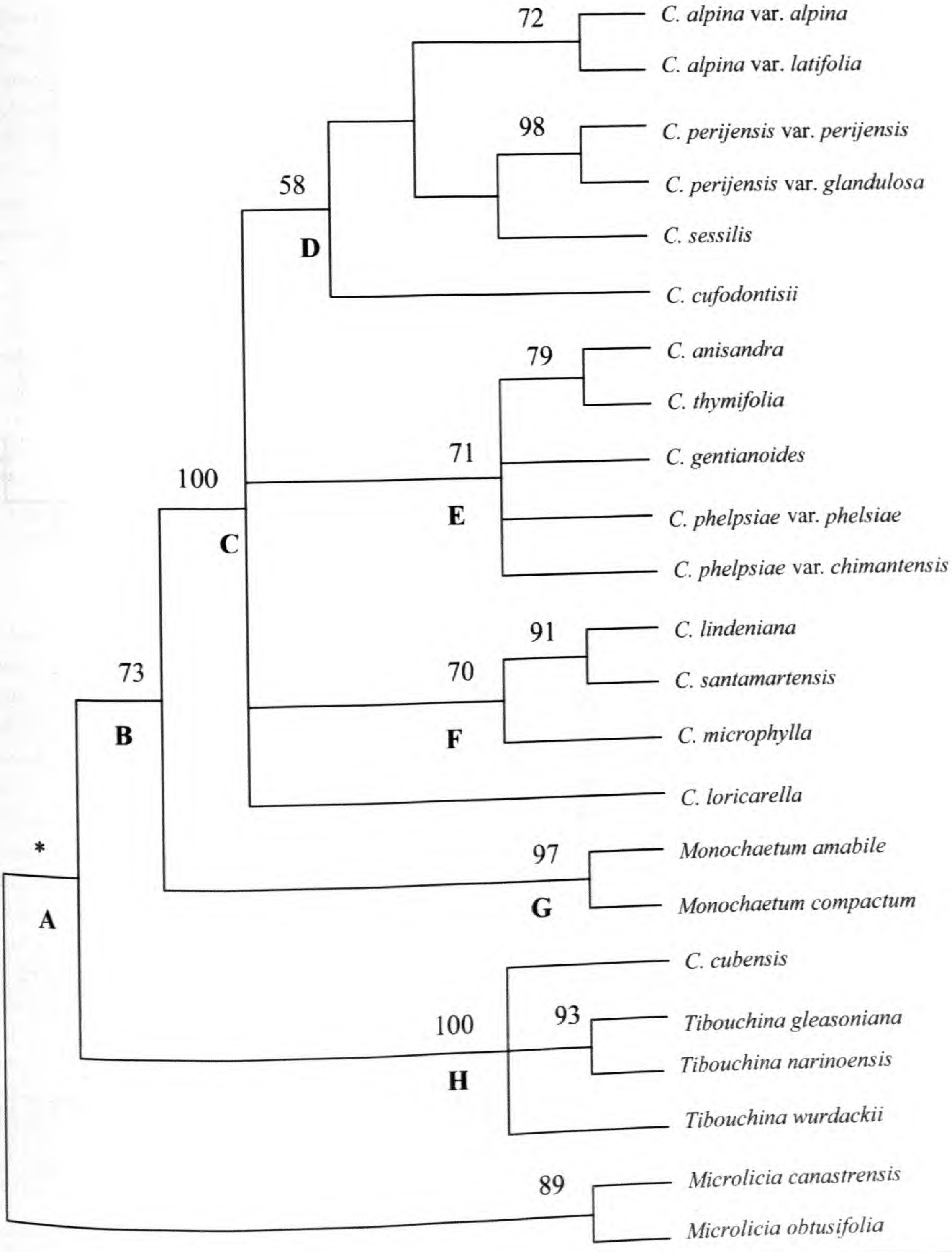


Fig. 2. Strict consensus tree generated from a branch and bound analysis of morphological characters and a backbone constraint, defining the outgroups as *Monochaetum*, *Microlicia*, *Tibouchina*, and *Chaetolepis cubensis* (analysis 2). Bootstrap values greater than 50% are shown above the branches. Letters represent the nodes above them. An " * " is used to represent the node of the backbone constraint.

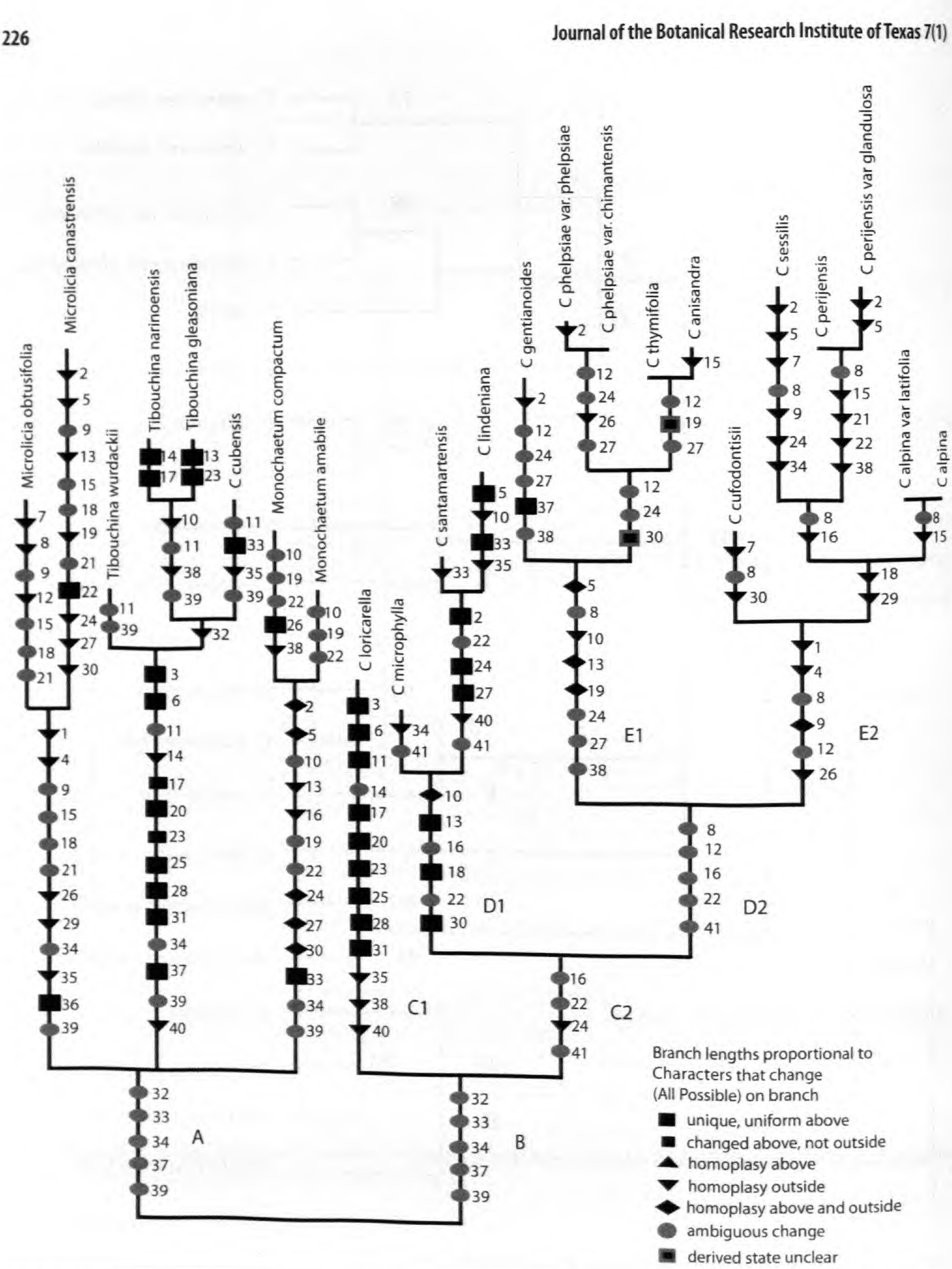


FIG. 3. One of twenty-six most parsimonious trees generated from a branch and bound analysis of the ingroup, *Chaetolepis*, and the outgroups *Microlicia*, *Monochaetum*, and *Tibouchina* (analysis 2). Character numbers are shown to the right of the hash mark. Letters A,B,C,D, and E represent nodes to the left of them.

yellow petals. The homoplasious characters are smooth eglandular trichomes, smooth glandular trichomes, or barbellate trichomes on the intercalycine lobe sinus. Clade D1 is supported by six characters, of which three are unique, two are ambiguous, and one is homoplasious. The unique characters are roughened trichomes on the abaxial leaf surface (between primary veins), branch surface internodes, and calyx midrib (characters 13, 19, 30). The ambiguous characters are roughened trichomes on the abaxial leaf surface (on the primary veins) and branch surface nodes (character 16 and 22). The homoplasious character is roughened trichomes on the adaxial leaf surface (character 10). There are five ambiguous characters supporting clade D2 which include a crenulate or serrulate leaf margin, punctate or sessile glands on the abaxial leaf surface, smooth eglandular trichomes or smooth glandular trichomes on the abaxial leaf surface, branch surface nodes are glabrous or with smooth eglandular trichomes, and yellow petals (characters 8, 12, 16, 22, 41). Clade E1 is supported by eight characters, of which four are ambiguous and four are homoplasious. The four ambiguous characters include a crenulate leaf margin, forked intercalycine lobe sinus, calyx vestiture that is absent or with smooth eglandular or smooth glandular trichomes, and three to five leaf veins (characters 8, 24, 27, 38). The four homoplasious characters include a hypanthium apex, adaxial leaf surface, abaxial leaf surface (between primary veins), and branch surface internodes with smooth and elgandular trichomes (characters 5, 10, 13, 19). Clade E2 is supported by six characters of which two are ambiguous and four are homoplasious. The ambiguous characters are a serrulate leaf margin and punctate abaxial leaf surface (characters 8 and 12). The homoplasious characters are sessile glands on the hypanthium base, hypanthium apex, adaxial leaf surface, and calyx vestiture (characters 1, 4, 9, and 26). There are six characters supporting the clade consisting of only *C. gentianoides*, one of which is unique, four of which are ambiguous, and one of which is homoplasious. The unique character is a seed testa with elongate, interdigitating cells. The ambiguous characters are abaxial leaf surface lacking glands, stalked and variously branched trichomes at the intercalycine lobe sinus, smooth eglandular trichomes on the calyx lobes, and five elevated leaf veins (characters 12, 24, 27, 38). The homoplasious character is smooth eglandular trichomes on the hypanthium base (character 2). There are three characters supporting the clade that includes *C. phelpsiae* var. *phelpsiae*, *C. phelpsiae* var. *chimantensis*, *C. thymifolia*, and *C. anisandra*, one of which is an unclear derived state. This latter character state is smooth eglandular trichomes and smooth glandular trichomes on the calyx lobes (character 30). The ambiguous characters are smooth eglandular trichomes on the abaxial leaf surface and forked trichomes on the intercalycine lobe sinus (characters 12 and 24). Three characters support the clade consisting of *C. thymifolia* and *C. anisandra*, two of which are ambiguous and one of which is an unclear derived state. The two ambiguous characters are abaxial leaf surface with sessile glands (character 12) and calyx vestiture devoid of scales (character 27).

Historical Biogeography.—The first Fitch optimization analysis, which is four steps long, places the Andes at the most basal node (Fig. 4). One dispersal each from the Andes to West Africa, Costa Rica, and Venezuelan Guayana is inferred. The results of the second Fitch optimization analysis, which is nine steps long, are largely ambiguous (not shown). However, a majority of the most parsimonious reconstructions (20 of 32) of this analysis places Sierra Nevada de Santa Marta at the most basal node.

DISCUSSION

I. Cladistic Analysis

Monophyly of Traditionally Circumscribed Chaetolepis.—The cladistic analysis indicates that *Chaetolepis* is not monophyletic as traditionally circumscribed because *C. cubensis* is more closely related to the outgroup taxa *Tibouchina gleasoniana*, *Tibouchina narinoensis*, and *Tibouchina wurdackii* than to other congeners (Fig. 1). *Chaetolepis cubensis* and the species of *Tibouchina* in the outgroup share a tuberculate seed testa (Fig. 6 d–f) and trichomes modified into scales that are adnate to the foliar epidermis (adaxial surface) for ⅓ to ⅔ of their length. This species was probably transferred to *Chaetolepis* by Triana (1871) because of its four-merous flowers, markedly reduced pedoconnective and inconspicuous ventral staminal appendage. Our results, however, demonstrate that the above characters are not synapomorphies for the genus. Based on the phylogenetic results and the character differences, we propose the return of *C. cubensis* to *Tibouchina* (see Excluded Species).

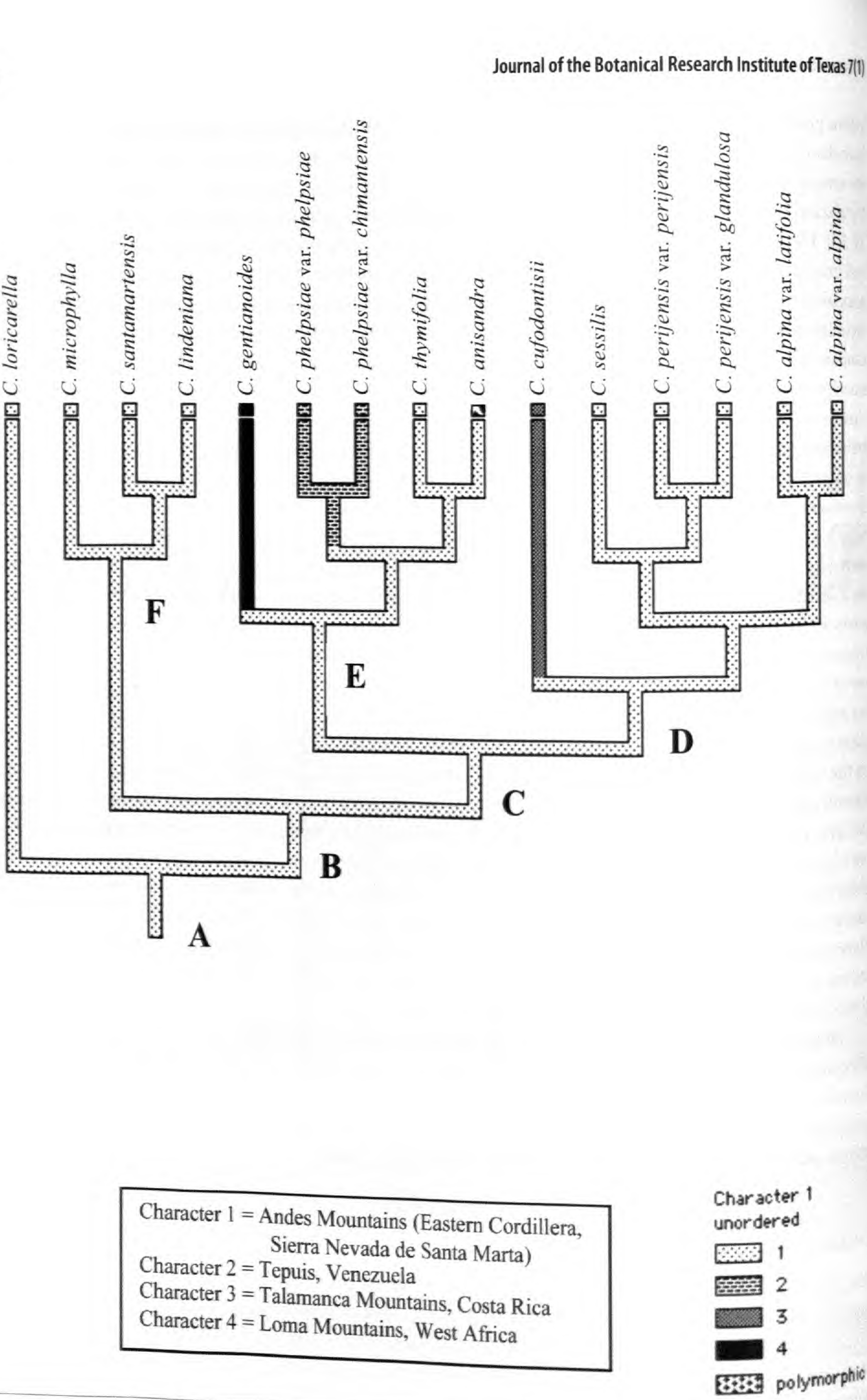


FIG. 4. A Fitch optimization using 4 areas and 1 of 26 tree topologies generated from a branch and bound search of *Chaetolepis* (analysis 2).

Likely sister outgroup of Chaetolepis when excluding C. cubensis (Chaetolepis sensu stricto).—An analysis of morphological data used in this study suggests that *Monochaetum*, not *Tibouchina* as proposed by Wurdack (1973), is likely sister to *Chaetolepis* sensu stricto. The characters that support this relationship are a dorsal orientation of the anther pore, four-merous flowers (Fig. 3). However, it cannot be ascertained from this study whether these are synapomorphies for *Chaetolepis* and *Monochaetum* or for the remainder of the outgroup. Additional similarities between *Chaetolepis* and *Monochaetum* include a four-locular ovary, cochleate seed shape, compressed/flattened cells of the seed testa, a montane habitat in tropical America, and a chromosome number based on x = 9 (Almeda and Chuang 1992; Solt and Wurdack 1980), although the latter two characters may ultimately be demonstrated to be symplesiomorphies for these genera.

Infrageneric relationships and character evolution.—Despite the fact that the strict consensus tree exhibited several areas of nonresolution, four major clades were resolved (clades D, E, F and *Chaetolepis loricarella* in Fig. 2). These clades are based largely on the kinds of trichomes found on various morphological organs, a character that Wurdack (1986) surmised was of phylogenetic importance among Melastomataceae. Trichome diversity in *Chaetolepis* includes scales, barbellate/dendritic trichomes, smooth eglandular trichomes or smooth glandular trichomes, and sessile glands. *Chaetolepis loricarella* is the only species in the ingroup with an indument of scales: thus this character is autapomorphic within *Chaetolepis*.

The clade comprising *Chaetolepis microphylla, C. santamartensis,* and *C. lindeniana* (Fig. 3, Clade D1) in the second cladistic analysis showing character state change is supported by four unambiguous characters whose character states all involve barbellate trichomes. The only other species in the analysis that has barbellate trichomes is *Monochaetum compactum* (a species within the outgroup). Thus this character state is likely to be derived within *Chaetolepis*. Similarly, the clade comprising *Chaetolepis gentianoides, C. phelpsiae* var. *phelpsiae, C. phelpsiae* var. *chimantensis, C. thymifolia,* and *C. anisandra* (Fig. 3, Clade E1) is supported by four unambiguous characters states that all involve smooth eglandular trichomes. The only other species in the analysis that has this character is *Monochaetum amabile*. Thus this character state is also likely to be derived within *Chaetolepis*.

—The clade comprising *Chaetolepis cufodontisii, C. perijensis* var. *perijensis, C. perijensis* var. *glandulosa, C. alpina* var. *alpina,* and *C. alpina* var. *latifolia* (Fig. 3, Clade E2) is supported by four unambiguous characters whose character states all involve the presence of sessile glands on the adaxial leaf surface. This is clearly a derived character state within *Chaetolepis* for these characters.

—*Chaetolepis loricarella, C. lindeniana, C. santamartensis,* and all the outgroup taxa have magenta colored petals (including *C. cubensis*), whereas all other species of *Chaetolepis* have yellow petals. Although yellow petals are ambiguously placed in the character optimizations (character 41; see Fig. 3), it is clearly derived within *Chaetolepis*. The same three *Chaetolepis* spp. sensu stricto have petals with ciliate margins, as do *C. cubensis* and all species of *Tibouchina*. This character is inferred to have evolved twice within *Chaetolepis*, as well as once within the outgroup, *Tibouchina*.

—*Chaetolepis gentianoides* from West Africa is the only species with elongate somewhat convex or domed periclinal walls on the seed testa (Fig. 6 g–i) but it is nested within *Chaetolepis* in the strict consensus tree of the second analysis. All other species of *Chaetolepis* have periclinal cell walls on the seed testa that are compressed/flattened and not conspiculously elongate (Figs. 5–6). The outgroup taxa have either a foveolate or tuberculate seed testa. Elongate interdigitating cells on the seed testa appear to have evolved only within *C. gentianoides* and is thus autapomorphic. An expanded survey of seed micromorphology may provide a clue to possible relationships of this species with other genera of the tribe Melastomeae in Africa.

Historical Biogeography.—The first Fitch optimization supports the eastern cordillera of the Colombian and Venezuelan Andes as the place of origin for the genus (Fig. 4). The second Fitch optimization analysis suggests an origin in the Sierra Nevada de Santa Marta, although a minority of various other equally optimal reconstructions of area onto the topology result in different scenarios. The Sierra Nevada de Santa Marta in far northern Colombia and its nearest montane neighbor, the Sierra de Perijá (a branch of the eastern cordillera of the Colombian Andes) are distinct mountain systems with independent origins (Todd & Carriker 1922; Irving

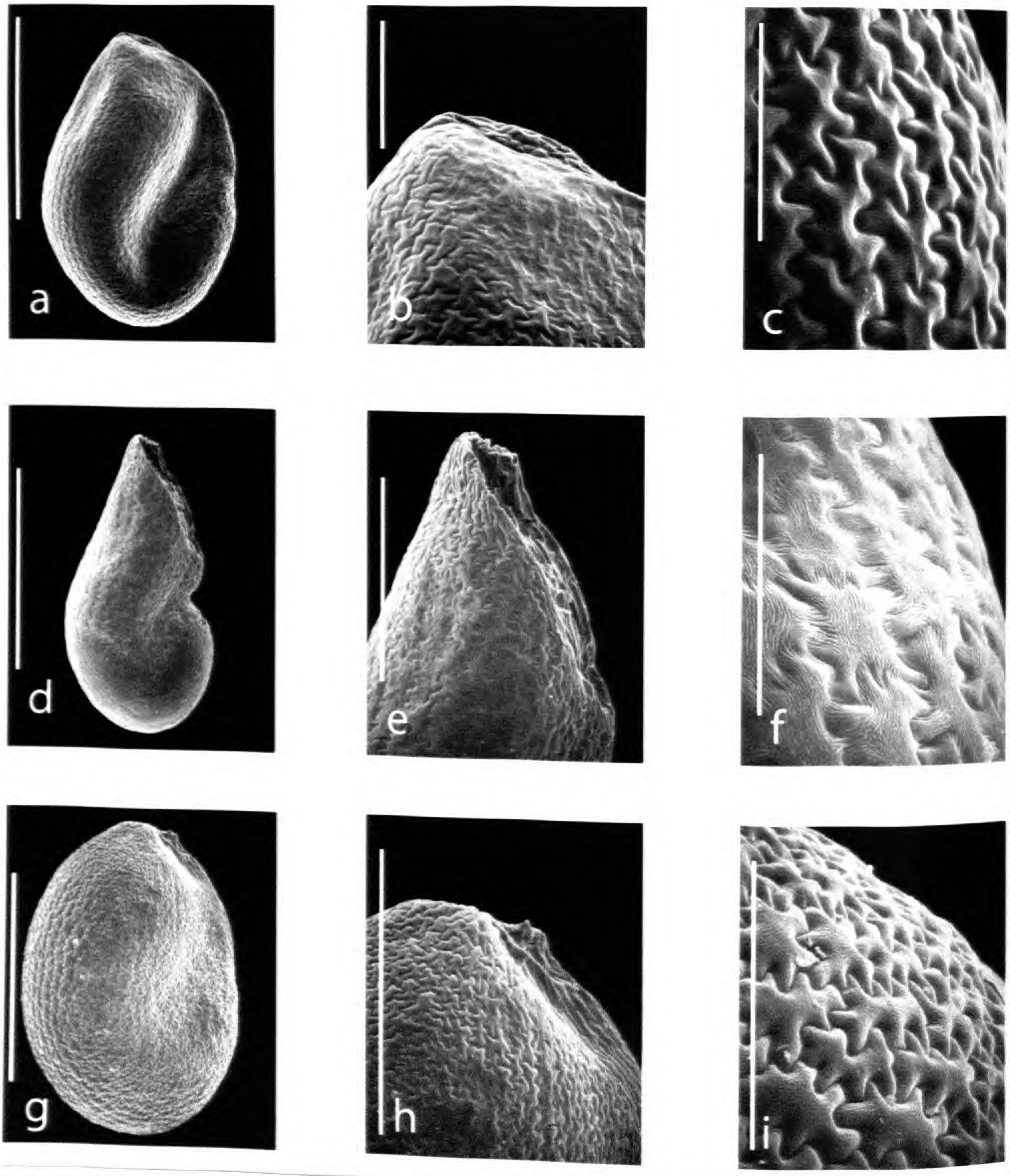


Fig. 5. Scanning electron micrographs of *Chaetolepis* seeds. **a–c.** *C. alpina* (*Killip & Smith 18214*): **a.** Profile view; **b.** Enlarged portion of seed coat; **c.** Enlarged portion of seed coat. **d–f.** *C. lindeniana* (*Killip & Smith 19596*); **d.** Profile view; **e.** Enlarged portion of seed coat; **f.** Enlarged portion of seed coat. **g–i.** *C. microphylla* (*McDougal & Roldan 3640*); **g.** Profile view; **h.** Enlarged portion of seed coat; **i.** Enlarged portion of seed coat. Scale bars: a = 0.3 µm, b = 0.07 µm, c = 0.10 µm, d = 0.35 µm, e = 0.28 µm, f = 0.05 µm, g = 0.25 µm, h = 0.17 µm, i = 0.08 µm.

1975). The Sierra Nevada de Santa Marta is the most northern and isolated land mass in northern Colombia. It has often been considered part of the Andean region (Simpson 1975; Rangel-Ch. & Garzón-C. 1997). This massif was underwater until the mid-Tertiary but its uplift began in the late Miocene and continued with substantial block-lifting in the early Pleistocene (Gansser 1955; Simpson 1975). Uplift of the eastern cordillera of Colombia and adjacent Venezuela (including the Sierra de Perijá and Mérida Andes) began in the Upper Creta-

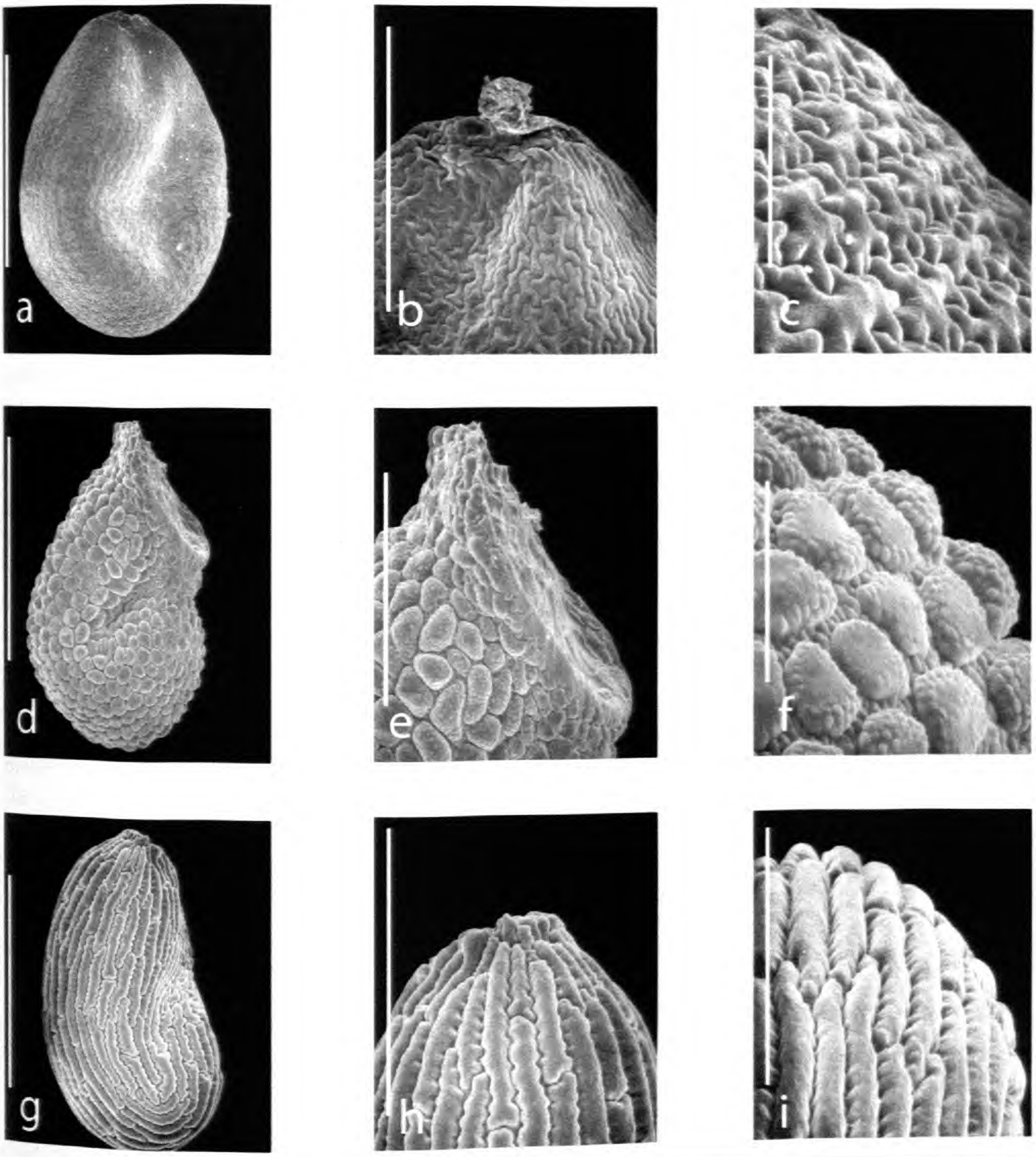


Fig. 6. Scanning electron micrographs of *Chaetolepis* seeds. **a–c.** *C. anisandra* (*Tate 153*): **a.** Profile view; **b.** Enlarged portion of seed coat; **c.** Enlarged portion of seed coat. **d–f.** *C. cubensis* (*Killip 42939*): **d.** Profile view; **e.** Enlarged portion of seed coat; **f.** Enlarged portion of seed coat. **g–j.** *C. gentianoides* (*Jacques-Félix 235*): **g.** Profile view; **h.** Enlarged portion of seed coat; **i.** Enlarged portion of seed coat. Scale bars: a = 0.3 µm, b = 0.07 µm, c = 0.10 µm, d = 0.35 µm, e = 0.28 µm, f = 0.05 µm, g = 0.25 µm, h = 0.17 µm, i = 0.08 µm.

ceous but substantial uplift above surrounding terrain was only achieved in Tertiary time beginning in the Paleocene with continued upward movement culminating in the Pliocene (van der Hammen 1961; Irving 1975; Simpson 1975).

Renner and Meyer (2001) postulated that the occurrence of *Chaetolepis gentianoides* in West Africa resulted from a long-distance dispersal event because of the "great morphological similarity between certain" South American "and West African taxa" of Melastomataceae. Our data appear to support this hypothesis. In a similar study using molecular data, Givnish et al. (2004) concluded that long-distance dispersal was also re-

sponsible for the present distribution pattern of *Pitcairnia* L' Hér. (Bromeliaceae), a genus centered in tropical America with one endemic species in West Africa [*Pitcairnia feliciana* (A. Chev.) Harms & Mildbr.]. That study postulated that many other South American-African disjuncts (see Thorne 1973; 1992) have resulted from long-distance dispersal rather than vicariance events, because the split of these two continents is too old (ca. 80 million years) to account for many disjuncts, especially those that are highly similar morphologically, such as *Chaetolepis*. The timing of dispersals to Africa from the Andes cannot be estimated because data from the present study are based only on branching patterns, and not branch lengths. An independent test of whether the amphi-Atlantic disjunction in *Chaetolepis* is due to ancient vicariance or more recent-long distance dispersal, as well as the timing of the other two dispersals inferred from the data (Venezuelan Guayana and Talamanca Range) will require clade divergence estimates based on molecular data, such as DNA sequences.

As for the distribution of *Chaetolepis* species within South America, long distance dispersal of different taxa within Melastomataceae, Bromeliaceae, Cactaceae, and other families likely occurred intermittently within South America because of climatic fluctuations during the Pleistocene, a period extending from 1.8 million to 11,550 years ago (Berry 1982). The movement of species within South America and beyond is speculative but it may have been aided by bird migration. As bird species, like the Swainson's Hawk (*Buteo swainsoni* Bonaparte), traveled to breeding or wintering grounds along the Atlantic Coastal flyway or bird species like the Arctic Tern (*Sterna paradisaea* Pontoppidan) migrated annually across the Atlantic from North America to Europe, West Africa, and South America and back they may have unintentionally picked up *Chaetolepis* seeds on their feet as they walked through mud in search of food (Lincoln et al. 1998). The Arctic Tern is the only example of a bird with a migratory path passing through both South America and Africa, but it is not known to frequent higher elevations in West Africa where *Chaetolepis* occurs. Further studies using molecular data are needed to confirm or reject the placement of *C. gentianoides* in the genus and to estimate divergence times that could assess the likelihood of long distance dispersal to Africa.

Venezuelan Guayana taxa such as *Chaetolepis phelpsiae* var. *phelpsiae* and *C. phelpsiae* var. *chimantensis* in clade E may have evolved as a result of vicariance. These species are closely related and have ranges that are adjacent to one another. Probably through time, erosion of the sandstone landmass of the tepui landscape isolated populations and led to speciation. Givnish et al. (2004) estimated that "chemical dissolution and erosion should cause the margins of adjacent tepuis to retreat from each other at a rate of nearly 2.4 km/million years. Such low rates would permit vicariance to play a role only on tepuis that are currently quite close to each other. Vicariance seems unlikely to have played a role in speciation on tepuis that are now further apart than ca. 35 km."

II. Chromosome Cytology

Meiotic chromosome numbers have been published for three species of *Chaetolepis*.

Favarger (1962) reported $n = 9$ for *C. gentianoides* (as *Nerophila gentianoides* Naudin) and Solt & Wurdack (1980) reported $n = 9$ for *C. microphylla* and $n = 18$ for *C. lindeniana*. We report here the first count for *C. cufodontisii*; $n = 9$. In this species meiosis was regular in all cells studied and all figures examined at diakinesis and telophase II were clear and consistent (Fig. 7). Present data indicate that the base number for *Chaetolepis* is $x = 9$. A base number of $x = 12$ has repeatedly been invoked as the original base number for the Melastomataceae and the order Myrtales (Raven 1975; Johnson & Briggs 1984; Graham et al. 1993; Almeda 1997a; Almeda & Robinson 2011). A base number of $x = 9$ could be derived through descending dysploidy. Thus, the three species of *Chaetolepis* with $n = 9$ have retained the base chromosome number in the genus whereas *C. lindeniana*, with $n = 18$, is clearly tetraploid based on $x = 9$. Among the significant outgroups and sister genera of *Chaetolepis*, *Bucquetia* DC. has $n = 18$ (Solt & Wurdack 1980); *Monochaetum* (DC.) Naudin has $x = 18$ (Almeda 1997b); and *Tibouchina* Aubl. has $x = 9$ (Almeda 1997b). No chromosome numbers are known for the ditypic genus *Castratella* Naudin. Of the five patterns of chromosomal evolution proposed to account for the origin and diversity of numbers for neotropical Melastomataceae (Almeda 1997b; Almeda 2013; Almeda & Chuang 1992), *Chaetolepis* appears to fit the one in which intrageneric euploidy has played a role in speciation whereas the origin of closely related genera such as *Bucquetia* and *Monochaetum* can be accounted for by paleopolyploid events.

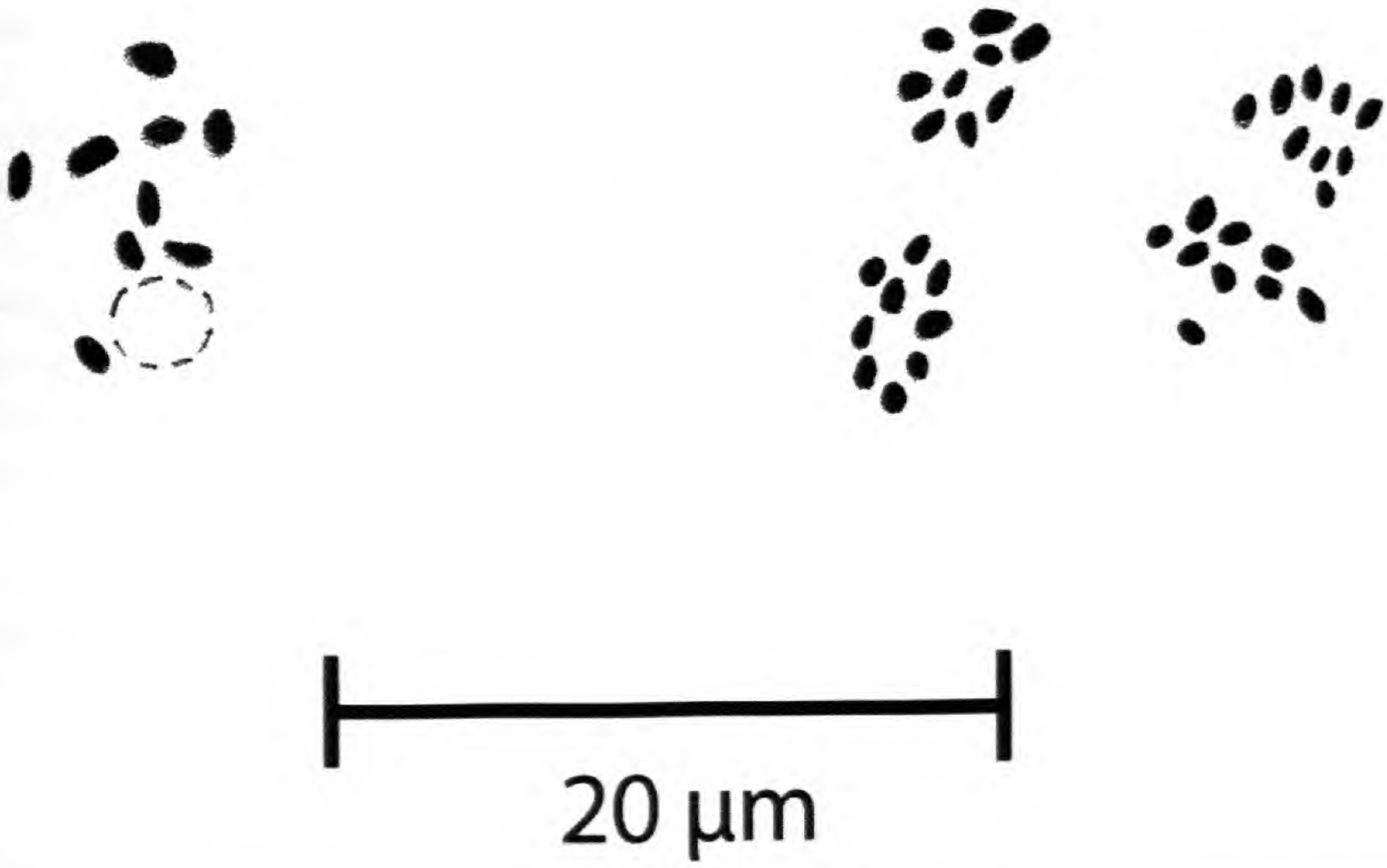


Fig. 7. Camera lucida drawings of meiotic chromosome figures of *Chaetolepis*. Meiotic stages are indicated by DIAK (diakinesis), TII (Telophase II). **a.** *C. cufodontisii*, n = 9, DIAK. **b.** *C. cufodontisii*, n = 9, TII.

III. Taxonomic Treatment

Chaetolepis Miq., Comm. Phyt. 72. 1840. *Rhexia microphylla* Bonpl., Rhex. 4, pl. 2. 1806–1808. Type: *Chaetolepis microphylla* (Bonpl.) Miq.

Erect or ascending, laxly or compactly branched *shrubs*, *subshrubs*, or annual *herbs*. *Distal cauline internodes* usually quadrate or subquadrangular, sometimes carinate; glabrous or covered with various kinds of trichomes, scales, or glands; *distal cauline nodes* somewhat thickened, often covered with trichomes, scales, or glands like those found on the internodes but trichomes and scales when present tending to be longer. *Older internodes* terete. *Principal leaves* opposite, coriaceous or membranaceous, spreading or tightly appressed; *adaxial and abaxial leaf surfaces* glabrous and punctate with sessile glands, or sparsely to densely covered with trichomes or scales; *blades* varying in shape from linear, oblong, elliptic, lanceolate, ovate, deltoid to obovate; with (1–)3–7 elevated, nearly parallel, longitudinal primary and secondary veins all arising from the blade base or with secondary nerves arising from the midnerve above the blade base; *margins* ciliate or eciliate, entire, crenulate, or serrulate, often revolute; blade *petiolate* or less commonly sessile or subsessile. *Inflorescences* terminal (sometimes terminal on axillary branches); *flowers* solitary, paired, or in simple dichasia (sometimes in compound dichasia). *Bracts* subtending the inflorescence similar to principal leaves in size, shape, and indument, persistent or deciduous. *Bracteoles* subtending individual flowers ranging from lanceolate, ovate, rhombic, oblanceolate, to narrowly ovate, smaller in size than bracts, persistent to deciduous. *Hypanthia (at anthesis)* urceolate to campanulate, ovary free from hypanthium, calyx lobes, petals, and stamens inserted on the torus; *Hypanthia (at maturity)* similar to hypanthia at anthesis in both size and shape but the vascular ribs conspicuous or sometimes cryptic upon drying. *Calyx lobes* persistent, erect to spreading, deltoid to narrowly triangular or lance-triangular, apically acute sometimes rounded, margin fringed with smooth eglandular or glandular trichomes. *Petals* four, nearly horizontal at anthesis, obovate, yellow or magenta, entire, ciliate or rarely erose at the margins, apex varying from cuspidate to obtuse, glabrous, with or without a terminal trichome. *Stamens* 8, isomorphic, fertile; *filaments* yellow to pink or magenta when dry; *anthers* two-celled, glabrous, yellow or magenta, linear to arcuate, tapering apically to the dorsally or ventrally inclined pore, *apical pore* about 0.2 mm in diameter; *connective prolongation (pedoconnective)* absent to minutely prolonged below the anther thecae (< 1mm long), lacking dorsal or ventral appendages or if present then poorly developed. Ovary superior, enveloped

by the hypanthium, ranging from globose to ovoid, 4-locular, placentation axile, *base* glabrous, *apex* sparsely to densely covered with minute appressed trichomes that range from smooth and eglandular to barbellate, with a persistent crown of erect trichomes surrounding the base of the style; *style* glabrous, straight or slightly curved distally, varying from yellow to magenta; *stigma* truncate. *Fruit* a dry loculicidal capsule. *Seeds* 0.4–1 mm long, cochleate, slightly to strongly curved, light to dark brown, raphal zone occupying ⅕ to ⅓ the length of the seed, testa cells (with SEM) arranged in a ± regular to irregular interdigitating pattern; individual cells ± elongated, anticlinal boundaries with undulate, S-type, U-type, or V-type patterns, periclinal walls ± compressed/flattened or low-domed, microrelief smooth or inconspicuously striate. Chromosome number: $x = 9$.

Distribution.—A montane-tropical genus with a center of diversity in the Andes of Venezuela and Colombia with outlying species in the Sierra Nevada de Santa Marta of Colombia, and the Guayana Highlands of Venezuela/Guyana at 1400–4100 m. It also ranges to Costa Rica (Cordillera de Talamanca) at 2400–3600 m and West Africa from Senegal and eastern Guinea-Bissau to the Simandou Massif in Guinea, south to the Loma mountains and Mount Nimba of Sierra Leone, and east to the Man Massif in the Ivory Coast at 1700–2100 meters.

KEY TO THE SPECIES *CHAETOLEPIS*

1. Annual herb; periclinal walls of seed testa smooth, elongate and domelike; each intercalycine sinus with a bifurcate or trifurcate ± flattened trichome; restricted to tropical West Africa (Senegal, Guinea Bissau, Guinea, Sierra Leone, and the Ivory Coast) _____ **4. C. gentianoides**
1. Perennial shrub or subshrub; periclinal walls of seed testa appearing ± smooth and flattened, if low and domelike then not conspicuously elongate; each intercalycine sinus with one or more trichomes, if branched then not conspicuously stalked; neotropical (Costa Rica, Colombia, Venezuela/Guyana).
   2. Leaf margin eciliate and lacking trichomes modified into scales.
      3. Principal leaves linear-oblong; petioles 0.5–1.5 mm; hypanthium beset with sessile glands; adaxial leaf surface punctate; primary veins on the abaxial leaf surface with smooth eglandular trichomes; cauline internodes glabrous; Costa Rica _____ **3. C. cufodontisii**
      3. Principal leaves elliptic to oblong-elliptic, sessile; hypanthium with sessile glands and with smooth eglandular trichomes; adaxial leaf surface glabrous; primary veins on the abaxial leaf surface glabrous; cauline internodes punctate; Venezuela _____ **13. C. sessilis**
   2. Leaf margin ciliate (the minute cilia appressed, obscure and often caducous at maturity in C. perijensis) or if appearing entire then fringed (at least basally) with flattened scales that have erose margins and/or an apical seta.
      4. Leaf blade with a single prominent median vein evident on the abaxial surface.
         5. Hypanthium, abaxial leaf surface, and cauline internodes covered with flattened scales; petals magenta _____ **6. C. loricarella**
         5. Hypanthium, abaxial leaf surface, and cauline internodes with a varied indument but lacking flattened scales; petals yellow.
            6. Hypanthium with a uniform distribution of sessile glands _____ **8. C. perijensis** var. **perijensis**
            6. Hypanthium with a uniformly distributed mixture of sessile glands and stalked glandular trichomes _____ **9. C. perijensis** var. **glandulosa**
      4. Leaf blade with three or more prominent veins evident on the abaxial surface.
         7. Petals magenta or lilac-violet, the margins ciliate.
            8. Principal leaves 3-nerved; adaxial leaf surface with bulla based trichomes; pedicels 2–5 mm long; calyx lobes 0.8–1 mm wide, acute apically _____ **5. C. lindeniana**
            8. Principal leaves 5–7-plinerved; adaxial leaf surface with minutely barbellate trichomes; pedicels 1–2 mm long; calyx lobes 2.5–3 mm wide, rounded apically _____ **12. C. santamartensis**
         7. Petals yellow, the margins eciliate.
            9. Leaf margin entire; adaxial leaf surface, abaxial leaf surface, and cauline internodes covered with barbellate or dendritic trichomes with short or well-developed axes and a moderate number of short terete arms _____ **7. C. microphylla**
            9. Leaf margin crenulate; adaxial leaf surface, abaxial leaf surface, and cauline internodes not covered with barbellate or dendritic trichomes.
               10. Base of hypanthium with smooth eglandular trichomes _____ **10. C. phelpsiae** var. **phelpsiae**
               10. Base of hypanthium glabrous or with sessile glands.
                  11. Cauline internodes with smooth eglandular and smooth gland-tipped trichomes; primary and secondary veins on abaxial leaf surface variously beset with sessile glands and/or smooth gland-tipped and smooth eglandular trichomes; distal portion of hypanthium around the torus with smooth eglandular trichomes.
                     12. Abaxial leaf surface covered with sessile glands and smooth eglandular trichomes; calyx lobes midrib with smooth eglandular trichomes, otherwise glabrous _____ **2. C. anisandra**

12. Abaxial leaf surface punctate with smooth, eglandular trichomes and smooth gland-tipped trichomes; calyx lobes beset with sessile glands, stalked glandular and eglandular trichomes both on and off the midrib _____ **11. C. phelpsiae** var. **chimantensis**

11. Cauline internodes with sessile glands or sometimes replaced by smooth gland-tipped trichomes; primary and secondary veins on abaxial leaf surface glabrous; distal portion of hypanthium around the torus lacking smooth eglandular trichomes _____ **1. C. alpina**

1. Chaetolepis alpina Naudin, Ann. Sci. Nat. Bot. sér. 3, 14:140. 1850. (**Figs. 5 a–c; 8**). TYPE: COLOMBIA: PROVINCE OF PAMPLONA: at 3000–3200 m, *Linden 724* (LECTOTYPE, designated by Martin & Cremers 2007: P!; ISOLECTOTYPES: BM!, BR! [2], F!, G!, K!, MPU, internet image, NY!).

Chaetolepis alpina var. *latifolia* Cogn., Monogr. Phan. 7:170. 1891. TYPE: VENEZUELA. PROVINCE OF CARACAS: *Funck 277* (LECTOTYPE, here designated: BR!; ISOLECTOTYPE: G!). The other syntype cited in the protologue, *Funck 484*, purportedly deposited at BR, was not seen.

Erect, compactly branched subshrub to 40 cm tall. Distal cauline internodes quadrate, winged, sparsely to moderately covered with sessile glands or sometimes intermixed with antrorsely spreading smooth eglandular trichomes. Distal cauline nodes like internodes except moderately covered with sessile glands intermixed with a sparse to moderate covering of smooth eglandular trichomes 1.5–2 mm long. Older internodes terete, woody and exfoliating with age. Principal leaves coriaceous, somewhat unequal in size in each pair; adaxially moderately covered with sessile glands; abaxially moderately punctate between primary and secondary veins, sparsely to moderately covered with smooth eglandular trichomes and sparsely to moderately covered with sessile glands on the elevated nerves or sometimes glabrous and without glands. Blades 8–13(16) × 2–3.5 mm, lanceolate, elliptic-lanceolate to lanceolate-ovate, acute to rounded apically, acute basally, the three prominent nerves extending the entire length of the blade; margins ciliate-serrulate; petioles 1–1.5 × 0.25–0.5 mm, moderately to densely covered with sessile glands. Inflorescence a simple to compound dichasium. Bracteoles 4–7 × 1–2(–3) mm, similar to principal leaves; margins ciliate-crenulate. Floral pedicels 0.8–1.2 mm long, glabrous. Hypanthia (at anthesis) 2.5–3.5 × 2–3 mm, urceolate or narrowly campanulate, yellow to magenta when dry, moderately covered with sessile glands; hypanthia (at maturity) with vascular ribs often conspicuous when dry. Calyx lobes 1.5–2 × 1–1.5 mm, erect to ascending, sometimes spreading to reflexed, deltoid to lance-triangular when dry, apically acute, ciliate, moderately covered with sessile glands; calyx moderately covered with sessile glands, sometimes with a smooth eglandular trichome on the midrib; intercalycine sinus with a smooth eglandular trichome, sometimes with a forked trichome. Petals 6–7 × 3–3.5 mm, yellow, apex cuspidate with a terminal trichome, margins entire, glabrous. Filaments 5–6 mm long, yellow; anthers 2.5–3 × 0.4–0.6 mm, yellow, linear; pore dorsally inclined; connective not prolonged below the thecae. Ovary sparsely or sometimes moderately covered with smooth eglandular trichomes; style 8–11 mm long, yellow. Seeds 0.5–0.6 mm long, brownish. Chromosome number: unknown.

Flowering.—Throughout the year.

Habitat and Distribution (Fig. 9).—Endemic to the Eastern Cordillera of Colombia in the departments of La Guajira, Santander, and Norte de Santander and the Sierra Nevada de Santa Marta in the departments of César and Magdalena at 1700–4100 meters. Found in subpáramos and páramos on rocky hillsides and cliffs.

Discussion.—Chaetolepis alpina is a laxly to compactly branched subshrub that is easily recognized by its sessile glands on adaxial foliar surfaces, cauline internodes, hypanthia, and calyx lobes. Other diagnostic characters include small lanceolate leaf blades that are 3-nerved; leaf margins that are ciliate-crenulate; an abaxial leaf surface that is punctate between the primary and secondary veins; and elevated veins that are covered with sessile glands and smooth eglandular trichomes.

Chaetolepis alpina is most similar to *C. perijensis*. Both species have sessile glands on their foliar surfaces, ciliate leaf margins, and punctate abaxial leaf surfaces between the primary and secondary veins. These two species also have smooth eglandular trichomes at the intercalycine sinuses; anthers with a pore that is dorsally inclined; and a seed testa that has compressed/flattened interdigitating cells. *Chaetolepis perijensis* differs from *C. alpina* by its sessile glands on cauline nodes, uninerved leaf blades with entire margins, and punctate abaxial leaf surfaces.

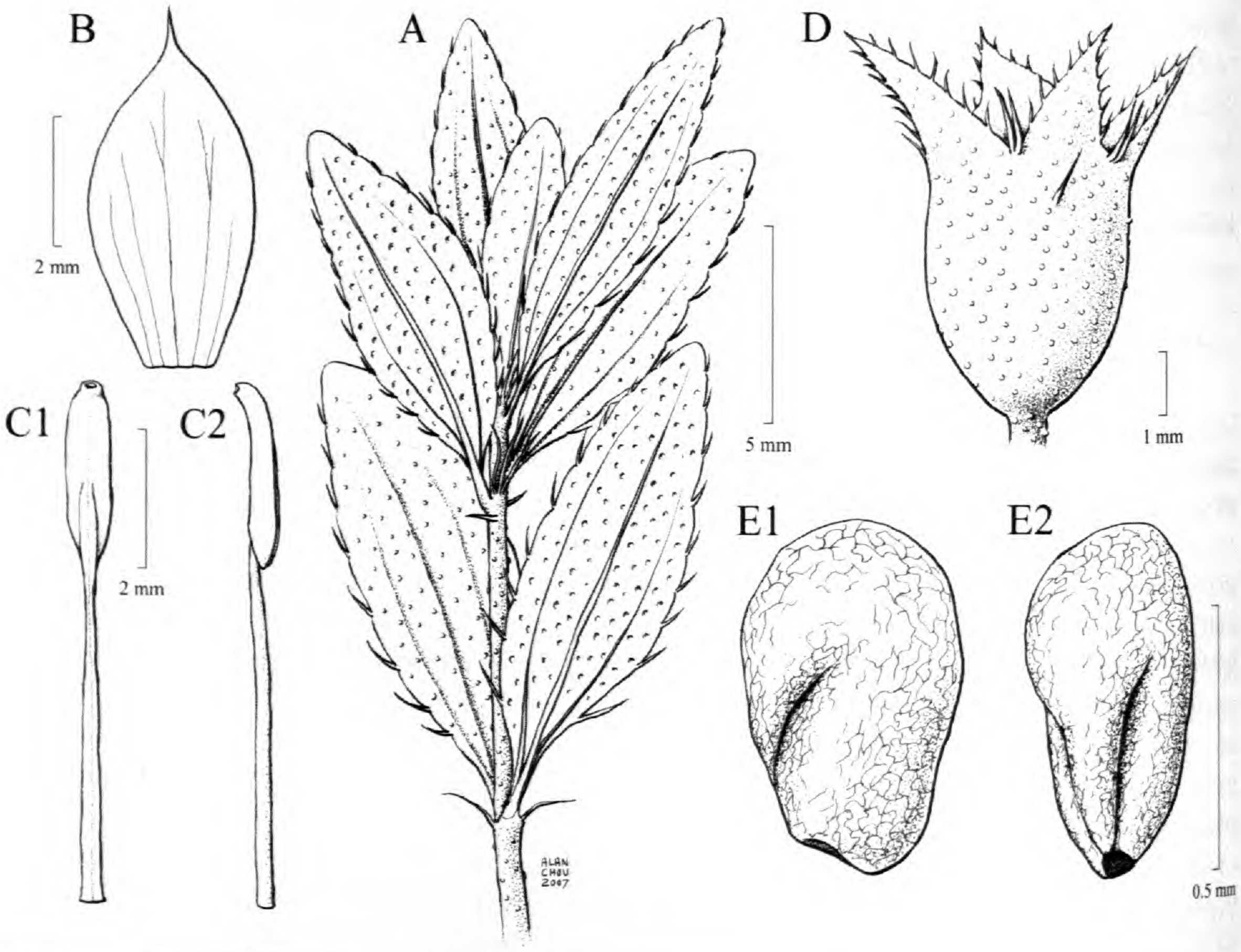


Fig. 8. *Chaetolepis alpina*. A. Habit. B. Petal (adaxial surface). C1. Stamen, dorsal view. C2. Stamen, profile view. D. Hypanthium. E1. Seed, profile view. E2. Seed, ventral view (A–E2 from *Cuadros & Gentry 2989*, US).

Chaetolepis alpina has been divided into two varieties, the nominate one and *C. alpina* var. *latifolia*. According to Cogniaux (1891) the nominate variety has oblong leaves 10–15 × 3–5 mm and var. *latifolia* has ovate leaves 8–13 × 4–8 mm. After study of many more collections than were available to Cogniaux, we could not detect non-overlapping morphological differences between the two. One collection, *Smith 768*, that was identified as *C. alpina* var. *latifolia* differed by its lack of foliar glands and presence of eglandular trichomes on the cauline internodes. In all other respects it is readily accommodated within *C. alpina*.

Additional specimens examined: **COLOMBIA. César:** Municipio Pueblo Bello, Nabusimake, *Stancik 190* (COL). **Norte de Santander:** Prov. de Pamplona, La Baja, *Funck & Schlim 1313* (BR). **La Guajira:** Riohacha, Macotama, Sierra Nevada de Santa Marta, *Carbonó 710* (UTMC); Sierra Nevada de Santa Marta, Vertiente Río San Miguel, *Cuadros & Gentry 2735* (MO); Serranía de Perijá, Cerro Pintado, *Cuadros & Gentry 3501* (MO). **Magdalena:** Sierra Nevada de Santa Marta, entre San Pedro y cabeceras del Río Sevilla, *Barclay & Juajibioy 6799* (COL, MO); Sierra Nevada de Santa Marta, Cerro Kennedy, *Cuadros & Gentry 2989* (US); Sierra Nevada de Santa Marta, se slopes, Hoya del Río Donachuí, *Cuatrecasas & Castaneda 24667* (NY); Sierra Nevada de Santa Marta, se slopes, Hoya del Río Donachuí, *Cuatrecasas & Castaneda 24857* (COL); Sierra Nevada de Santa Marta, camino entre quebrada Cebolleta y San Pedro, extremo oriental de la Cuchilla Yerbabuena, *Forero & Kirkbride 669* (COL, MO, NY, US); Sierra Nevada de Santa Marta, in San Sabastian de la Sierra, *Funck 484* (BM, BR, K); Sierra Nevada de Santa Marta, entre Canguruaca y Corisa, *van der Hammen 1136* (COL); Sierra Nevada de Santa Marta, Caserío de San Sebastian, *Rangel & Sturm 1863* (NY); Valledupar, San Sebastian de Rabago, *Romero-Castaneda 907* (COL); Sierra Nevada de Santa Marta, ca. 30 mi inland from Dibulla, *Seifriz 441* (NY); Sierra Nevada de Santa Marta, *Smith 768* (BR [2]); vicinity of two small lakes near source of Río Yebosimeina, *White & Alverson 582* (CAS, COL, MO, NY). **Norte de Santander:** hoya del Río Chitagá, Quebrada de Presidente, *Cuatrecasas 13489* (COL, F, US); Pamplona, por Garcia (sur de ciudad), *Fabrega 986* (F); Cucutilla, Páramo El Romeral, *Ortiz et al. NYO122* (COL). **Santander:** edge of Páramo de Santurbán, near Vetas, *Killip & Smith 17589* (F, GH, NY); vicinity of Vetas, *Killip & Smith 17901* (NY); Páramo de las Puentes, above La Baja, *Killip & Smith 18214* (GH, NY); Páramo de las Puentes, above La Baja, *Killip & Smith 18227* (NY); Páramo de las Coloradas, above La Baja, *Killip & Smith 18434* (NY); Ibid., *Killip & Smith 18467* (F, GH, NY, P); Páramo de Romeral, *Killip & Smith 18565* (BM, GH, MO, NY); western

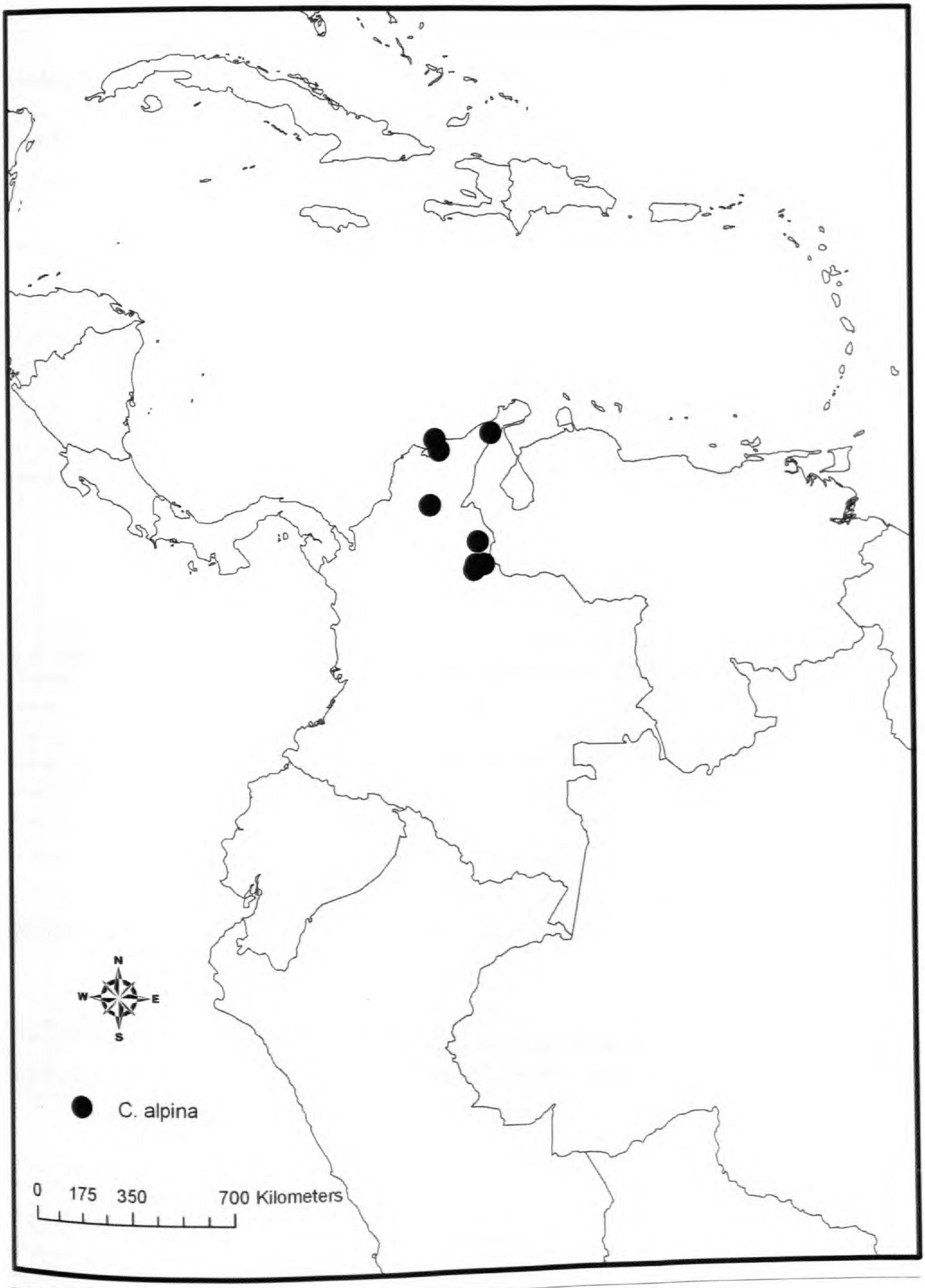


Fig. 9. Distribution of *Chaetolepis alpina*.

slope of Páramo de Santurbán, toward Tona, *Killip & Smith 19532* (GH, NY, US); Municipio de Cucutilla, Vereda El Carrizal, Páramo de El Romeral, *Sánchez et al. 5138* (HECASA); Municipio de Pamplona, Vereda El Volcán, *Solano et al. 35* (HECASA).

2. Chaetolepis anisandra Naudin, Ann. Sci. Nat., Bot. sér. 3, 14: 140. 1850 (**Figs. 6 a–c; 10**). TYPE: VENEZUELA. BOLÍVAR: near Mt. Roraima, *R. Schomburgk 663* (HOLOTYPE: P!; ISOTYPES: BM!, BR!, G!, K!, P, internet image!).

Chaetolepis thymifolia Triana, Trans. Linn. Soc. London 28:50. 1871. Syn. nov. TYPE: COLOMBIA. CUNDINAMARCA: Cordillera de Bogotá, in the Páramo de Choachi, elev. 3400 m, 1851–1857, *Triana 36178* (HOLOTYPE: BM, photo of holotype, F!; ISOTYPE : P!).

Chaetolepis citrina Gleason, Brittonia 3:174. 1939. TYPE: VENEZUELA. BOLÍVAR: Mount Auyan-tepui, elev. 2200 m, *G.H. Tate 1157* (HOLOTYPE: NY!; ISOTYPES: US, internet image!, VEN, internet image!).

A much branched subshrub 0.1–1 m tall. Older internodes woody, terete and exfoliating with age. Distal cauline internodes quadrate and carinate to narrowly winged, moderately to densely scabrous, the eglandular and glandular trichomes 0.4–0.5 mm long, appressed to ascending. Distal cauline nodes similar to distal cauline internodes but with trichomes 0.7–1 mm long. Principal leaves coriaceous, adaxial surface moderately covered with smooth, eglandular, evenly distributed spreading to erect trichomes; abaxial foliar surface moderately covered with sessile glands and sparsely covered with appressed or sometimes spreading, eglandular trichomes between the primary and secondary veins; moderately covered with sessile glands and moderately to densely covered with erect, eglandular trichomes on the primary and secondary veins; blades 6–12 × 4–9 mm, ovate to nearly deltoid, acute to broadly acute apically, cuneate basally, 3–5-nerved, the outer pair arising from the base and continuing one third or one half the length of the blade, margins ciliate-crenulate; petioles 2–4 × 0.25–0.5 mm, ciliate and/or sparsely beset with smooth trichomes but varying to glabrate. Inflorescence terminal, flowers solitary or borne in a simple 3-flowered dichasium. Bracts and bracteoles 5–9 × 3–6 mm, otherwise similar to the principal leaves, 3-nerved, sessile. Floral pedicels 0.5–1.0 mm long, or subsessile, moderately to densely covered with minute, erect trichomes. Hypanthia (at anthesis) 3–4.5 × 2–3 mm, campanulate, moderately covered with erect, smooth eglandular trichomes toward the apex, glabrous basally; hypanthia (at maturity) with vascular ribs often conspicuous when drying. Calyx lobes 2–2.5 × 1–1.5 mm, erect, narrowly triangular, apically acute, with 1 or more smooth eglandular trichomes and/or smooth glandular trichomes along the midrib, ciliate. Intercalycine lobe sinus with one or two forked trichomes or with a smooth eglandular trichome. Petals 7–9 × 4–5 mm, yellow, entire, glabrous, apically cuspidate, tipped with a single trichome. Filaments 3–9 mm long, yellow, anthers 2.5–4.5 × 0.5–1 mm, yellow, linear to arcuate, pore dorsally inclined; connective minutely prolonged 0.1–0.3 mm below the anther thecae. Ovary moderately covered apically with smooth eglandular trichomes. Style 6–7 mm long, yellow or pale brown when dry. Seeds 0.4–0.6 mm long, pale brown. Chromosome number: unknown.

Flowering.—September through January.

Habitat and Distribution (Fig. 11).—Mt. Roraima in Venezuela and Guyana (Wurdack et al. 1993) to Mt. Auyan-Tepui in Bolívar, Venezuela, from the sandstone bluffs to the summit at 1950–2600 meters. It also occurs on the Sierra de Perijá in Magdalena, Colombia, at 2700–2800 meters in páramo and cloud forest margins on the Sierra Nevada de Santa Marta and south of Bogotá in the Department of Cundinamarca, Colombia, in temperate forests, subpáramo, and páramo, along roadsides at 2500–3400 meters.

Discussion.—*Chaetolepis anisandra* is characterized by the smooth eglandular trichomes on distal portions of the hypanthium, both leaf surfaces, cauline nodes and internodes, and midrib of the calyx; and a glabrous hypanthium base (Fig. 10). The ovate to nearly deltoid leaf blades and sessile glands on the abaxial leaf surface (both on and between the primary and secondary veins) of this species also distinguish it from congeners.

Chaetolepis anisandra appears to be most closely related to *C. phelpsiae* var. *phelpsiae* based on morphological similarities as reflected in the strict consensus tree. Both species have eglandular trichomes on both leaf surfaces, cauline nodes, internodes, and midrib of the calyx lobes. Furthermore, these species both have ciliate-crenulate leaf margins, a leaf blade that is basally cuneate and 3-nerved, forked trichomes at the intercalycine lobe sinuses; inappendiculate anther connectives, and a dorsally inclined anther pore.

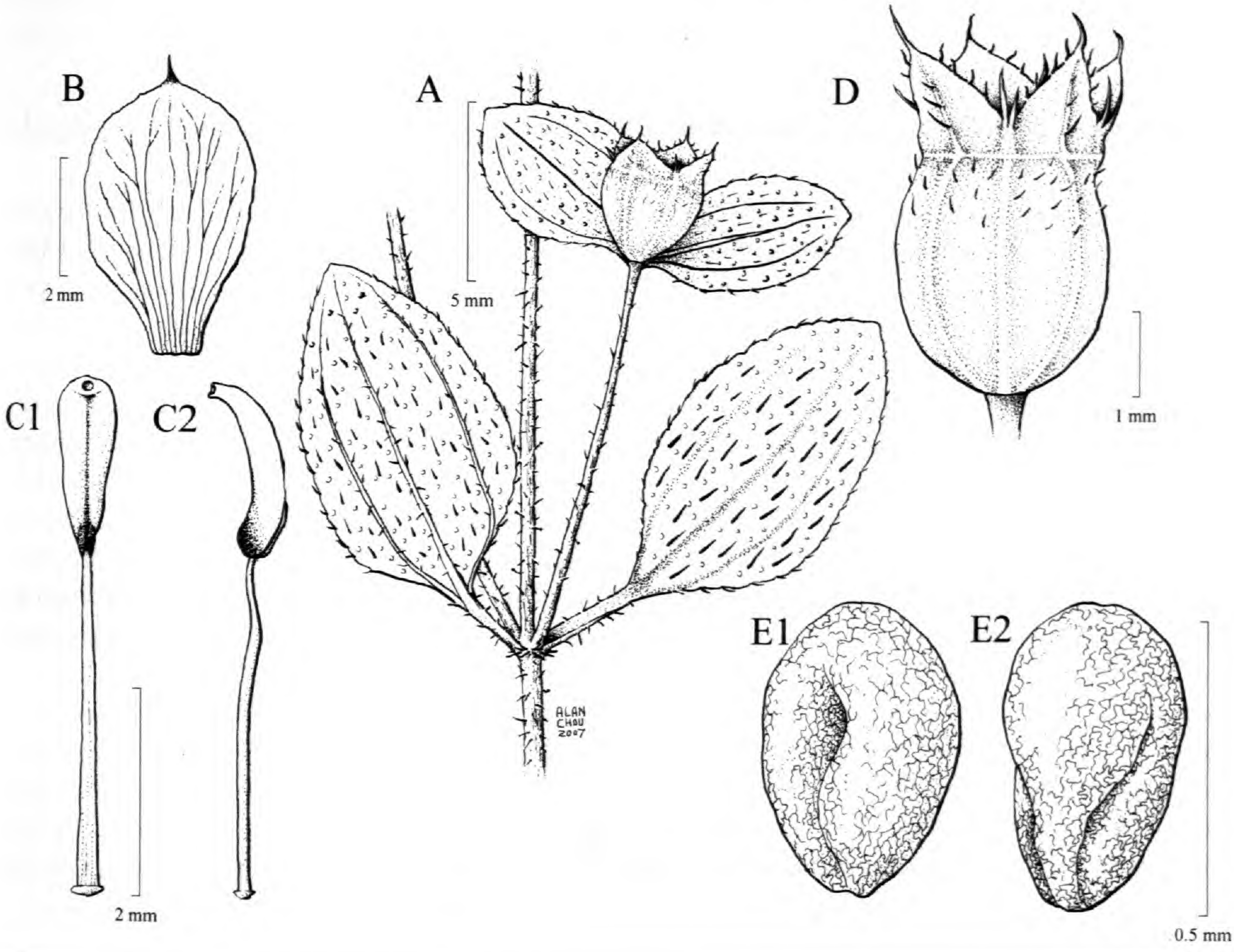


Fig. 10. *Chaetolepis anisandra*. A. Habit. B. Petal (adaxial surface). C1. Stamen, dorsal view. C2. Stamen, profile view. D. Hypanthium. E1. Seed, profile view. E2. Seed, ventral view (A–E2 from *Cardona 2720*, NY).

Chaetolepis phelpsiae var. *phelpsiae* differs from *C. anisandra* in having smooth eglandular trichomes that cover the entire hypanthium not just the distal region, an abaxial leaf surface that is punctate with eglandular and glandular trichomes between the primary and secondary veins, an abaxial leaf surface that has eglandular and glandular trichomes on the elevated veins, and cauline internodes that are sparsely covered with eglandular and glandular trichomes (Fig. 22).

Chaetolepis thymifolia has been recognized as a distinct species based on 3-nerved leaves and ovate to suborbicular petals (vs. 3–5-nerved leaves and obovate petals in *C. anisandra*). Because the petals of all species in the genus are obovate and foliar venation is consistently 3–5-nerved in *C. anisandra*, we see no reason to continue to recognize *C. thymifolia*. What has been recognized as *C. thymifolia* occurs in central Colombia at 2500–3400 m whereas *C. anisandra* has traditionally been accorded a range extending from northern Colombia to southeastern Venezuela at 1950–2800 m.

Representative specimens examined: **COLOMBIA. César:** Valledupar, páramo bajo entre Mamancana y Nabusimake, *Carbonó 3654* (UTMC). **Cundinamarca:** El Portachuelo between Une and Fosca, Cordillera Oriental vert. Oriental, en el mismo Boqueron, *Cuatrecasas & Jaramillo 28795* (US); Taguate Valley, 3 km W of Gutierrez, 45 km S of Bogotá, *Grant 9651* (NY, US); Páramo de Chipaque, *Karsten, s.n.* (BR, NY). **La Guajira:** Sierra de Perijá, E of Manaure, *Cuatrecasas & Castaneda 25164* (COL, F). **Magdalena:** Municipio de Santa Marta, Corregimiento de Minca, Sierra Nevada de Santa Marta, Cuchilla de San Lorenzo, road to Cerro Kennedy, *Almeda et al. 10152* (CAS, COL); Municipio de Santa Marta, Corregimiento de Minca, Sierra Nevada de Santa Marta, Cuchilla de San Lorenzo, Reserva Natural de Aves El Dorado, trail between Sendero Mirador and Sendero Quetzal Dorado, *Almeda et al. 10167* (CAS, COL); Municipio de Santa Marta, Sierra Nevada de Santa Marta, Estación San Lorenzo, *Carbonó 982* (CAS, UTMC). **VENEZUELA. Amazonas:** Serranía del Yutaje, Río Manapiare, *Maguire*

35322 (G). **Bolivar:** Mt. Auyan-Tepui, *Cardona 2720* (NY); Mt. Roraima, *Quelch & McConnell 22* (K); Mt. Roraima, ascent of ledge along SW facing side, *Steyermark 58735* (F, GH, NY); Mt. Roraima, *Quelch & McConnell 22* (K); Mt. Auyan-Tepui, *Steyermark 94072* (NY, US); Mt. Auyan-Tepui, *G.H. Tate 1157* (NY). Locality not given, *Schomburgk 1013* (F, GH).

3. Chaetolepis cufodontisii Standl., Publ. Field Mus. Nat. Hist., Bot. Ser. 18:792. 1938. (**Figs. 7, 12**). TYPE: COSTA RICA: *Endres s.n.* (HOLOTYPE: F!).

Erect, much-branched subshrub 10–40 cm tall. Distal cauline internodes quadrate, glabrous. Distal cauline nodes sparsely to moderately covered with spreading or appressed, smooth eglandular trichomes. Older branches woody, terete, and exfoliating with age. Principal leaves coriaceous, spreading, adaxial surface sparsely covered with sessile glands; abaxial surface moderately punctate, sometimes sparsely covered with antrorsely spreading trichomes between the primary and secondary veins, sparsely covered with eglanudar trichomes on the primary nerve, sometimes glabrous; blades 6–10 × 1–2.5 mm, lanceolate to oblong-lanceolate, acute to rounded apically, acute basally, 3-nerved with an elevated median nerve and depressed secondary nerves that extend the entire length of the blade; margin serrulate and eciliate; petioles 0.5–1.5 × 0.3–0.5 mm, glabrous. Inflorescence a simple, terminal dichasium, sometimes flowers solitary or paired. Bracts similar to principal leaves. Bracteoles 4–6 × 1–1.5 mm, also similar to principal leaves but subsessile or with petioles 1 mm long. Floral pedicels 0.5–2 mm long, glabrous. Hypanthia (at anthesis) 3.5–4.5 × 2.5–3.5 mm, urceolate to subcampanulate, sparsely covered with sessile glands; hypanthia (at maturity) with conspicuous longitudinal vascular ribs when dry. Calyx lobes 2.5–4 × 1–1.5 mm, erect to ascending, narrowly lance-deltoid, apically acute, ciliate; calyx lobes sparsely covered with sessile glands and with antrorsely spreading trichomes on the midrib, sometimes glabrous; intercalycine lobe sinus with one to three smooth flattened eglandular trichomes, these sometimes bifurcate. Petals 5–7 × 4–5 mm, yellow, apex acute, margin entire, glabrous except for a single terminal trichome. Filaments 4.5–5.5 mm long, yellow; anthers 2–3 × 0.4–0.6 mm, yellow, linear to arcuate; pore dorsally inclined; connective minutely prolonged 0.2–0.3 mm below the thecae. Ovary apex sparsely to moderately setose; style 9–10 mm long, yellow. Seeds 0.6–0.7 mm long, brown. Chromosome number: $n = 9$.

Flowering.—All year.

Habitat and Distribution (Fig. 11).—Endemic to Costa Rica in San José and Cartago provinces on the Cordillera de Talamanca in páramo on exposed slopes with shrubby vegetation at 2400–3600 m.

Discussion.—*Chaetolepis cufodontisii* is a much-branched subshrub readily recognized by the following characters: adaxial leaf surface and hypanthium covered with sessile glands; abaxial leaf surface punctate between the primary and secondary veins with a few eglandular trichomes on the elevated veins (Fig. 12); leaves with serrulate margins; glabrous cauline internodes; and dorsally inclined anther pores.

Chaetolepis cufodontisii most closely resembles *C. alpina* of Colombia. Both species have eglandular trichomes on the cauline nodes, an adaxial leaf surface covered with sessile glands, eglandular trichomes between the primary veins, and leaf blades that are 3-nerved. In addition these two species have hypanthia covered with sessile glands, smooth eglandular trichomes on the intercalycine sinuses, and anthers with dorsally inclined pores.

Chaetolepis alpina differs from *C. cufodontisii* by its ciliate-crenulate leaf margins, and sessile glands on the primary veins of abaxial leaf surfaces, cauline internodes, and calyx lobes.

Chaetolepis cufodontisii is also superficially similar to *C. sessilis* (Fig. 24). For major differences between these two species see the key to species.

Additional specimens examined: **COSTA RICA. Cartago:** Cordillera Talamanca, near Cerro de la Muerte, *Allen 5410* (F, G, NY, US); 1300 ft above highest point on highway, Cerro de la Muerte, Talamanca range, *Carlson 3526* (F, NY); Cerro de las Vueltas along the Pan American highway ca. 90 km S of Cartago, *Cronquist & Muños 8851* (NY); Cordillera de Talamanca, Asunción summit, Cerro de la Muerte, *Davidse & Pohl 1138* (CAS, MO); Páramo de Asunción, *Gomez et al. 2164* (MO); Cerro de la Muerte, Pan-American Highway, 5 km above Villa Mills and ca. 8 km above Nivel, *Holm & Iltis 556* (BM, DS, F, G, K, NY, P); Cerro Sákira, Macizo Buena, *Sánchez et al. 1398* (F, K); Cerro de la Muerte, Talamanca range, high point along Pan American highway, *Taylor 11758* (NY); slopes of Cerro Sákira at La Asunción along the Carretera Interamericana at km 91, *Wilbur & Stone 10043* (DUKE, F, US). **Heredia:** Zurquí [locality probably in error-unlikely it would be collected here] *Valerio 1205* (F). **Limón:** Cordillera de Talamanca, Atlantic slope, Cerros Tararia (locally known as Tres Picos), *Grayum et al. 28888* (CAS, MO). **San José:** Cerro Buenavista, ca. 10 km NW of the La Georgina Restaurant, en route to San José, area, *Almeda et al. 2349* (DUKE,

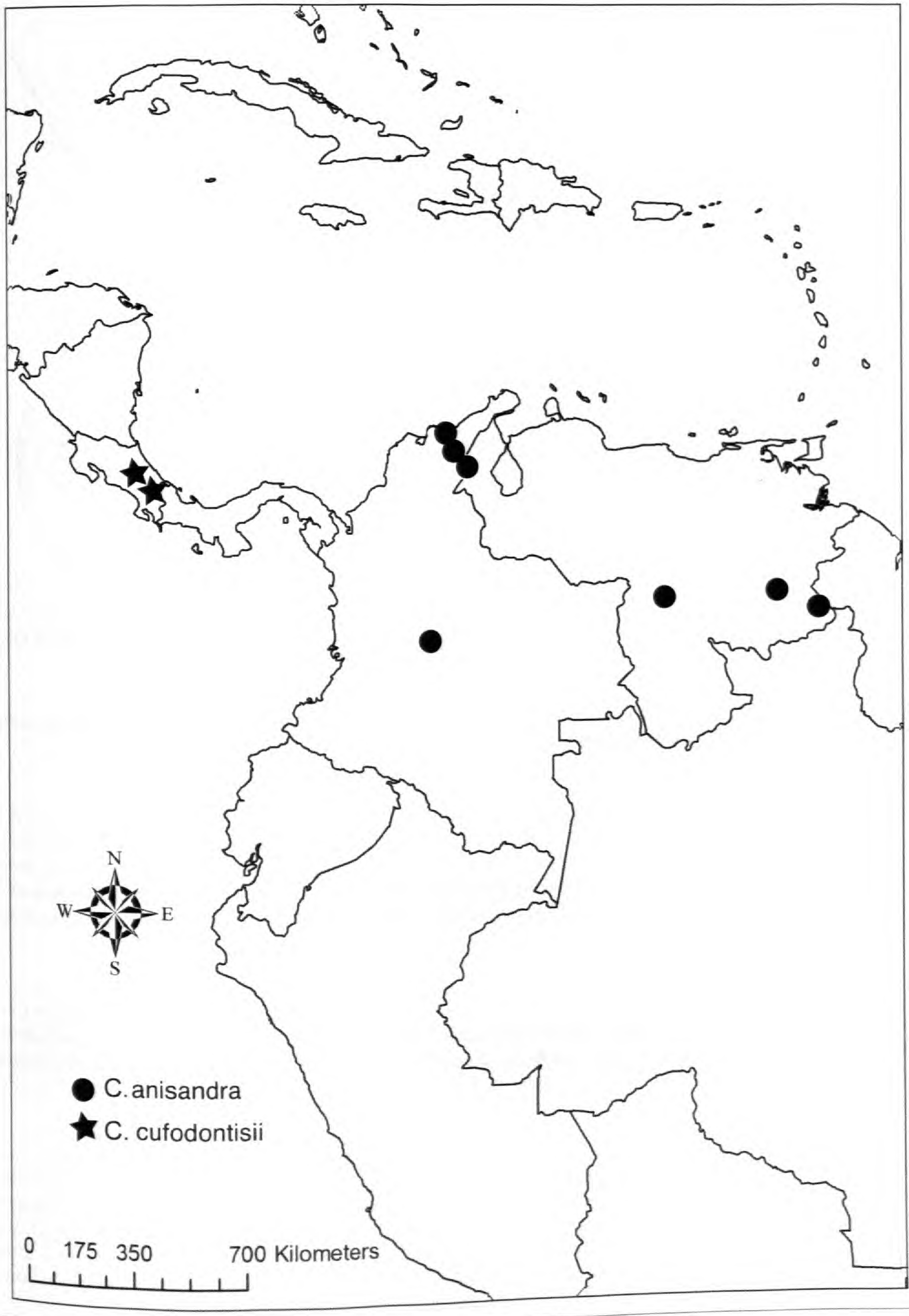


Fig. 11. Distributions of *Chaetolepis anisandra* and *C. cufodontisii*.

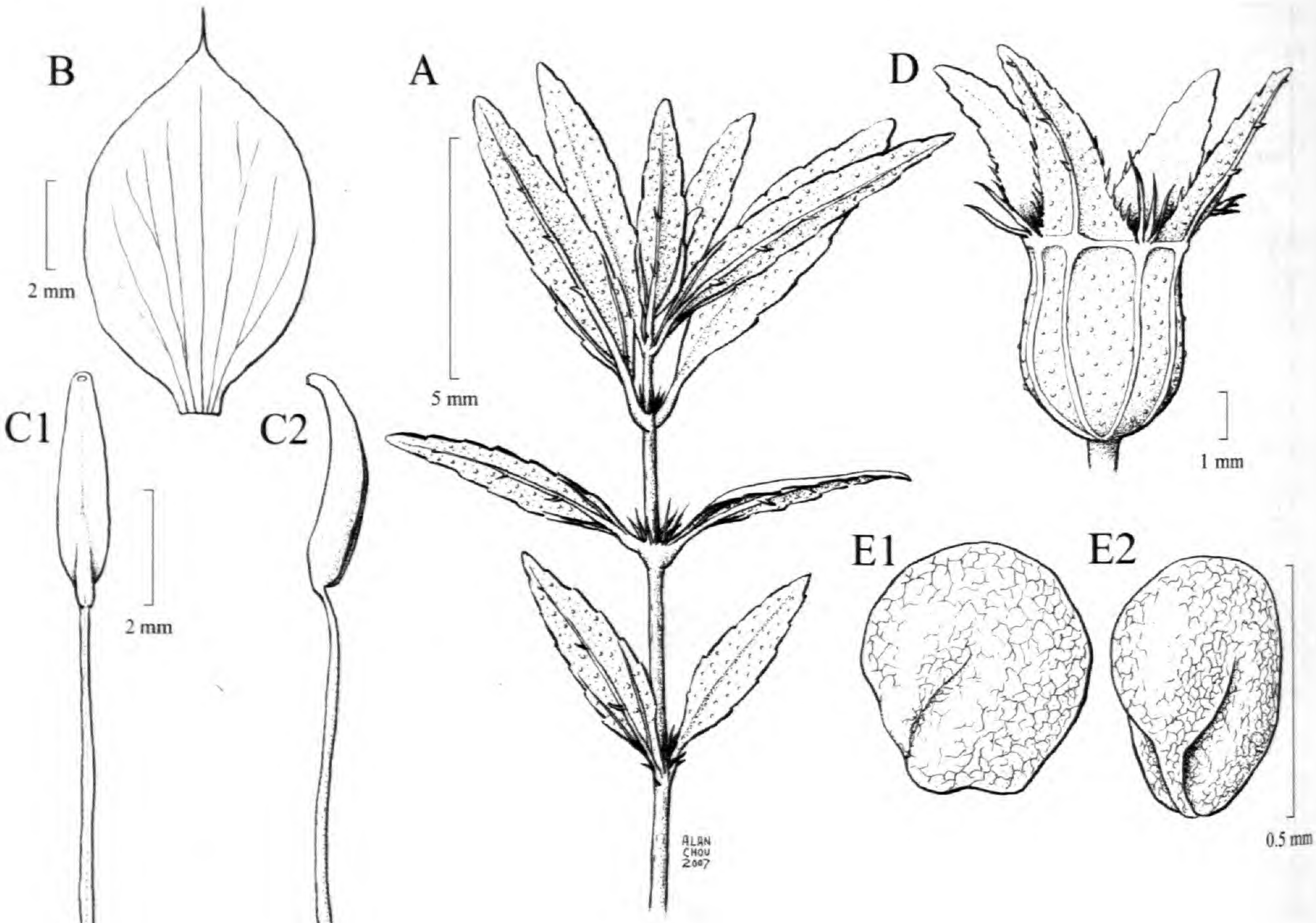


Fig. 12. ***Chaetolepis cufodontisii*****. A.** Habit. **B.** Petal (adaxial surface). **C1.** Stamen, dorsal view. **C2.** Stamen, profile view. **D.** Hypanthium. **E1.** Seed, profile view. **E2.** Seed, ventral view (A–E2 from *Almeda & Wilbur 1605*, F).

F); Cordillera de Talamanca, Vicinity of Cerro de la Muerte, *Allen 5410* (NY); direct line from Hotel La Georgina to Cerro Frío of the Cerro Buenavista complex (Cerro de la Muerte), area with television and radio towers, *Davidse 24987* (CAS, MO); Dos Burros, Cerro de la Muerte, *Dayton 3059* (F, MO); Buena Vista, *Jiménez 2662* (F); enroute to Cerro Chirripó from Canaan and on Pico Sudeste, *Weston 3652* (CAS); Buena Vista, *Jiménez 2663* (BM, NY); Pico Asunción, *Jiménez 3382* (F); Cantón Pérez Zeledán, Parque Nacional Chirripó, Valle de Los Conejos, trail to Cerro Chirripó, *Luteyn & Chaverri 15419* (CAS, NY); Páramo de Abejonal, *Pittier 7823* (BR[3], G); along Interamerican highway ca. 25 km SW of road to La Cima and 4.1 km NW of Cerro Asunción, E end of abandoned section of road, *Stevens 14298* (BM, CAS, F); Copey, *Tonduz 11903* (F); Los Frailes, *Valerio 1373* (BR, F); Cerro Buenavista, between Buvis summit and lower slopes of Frio, Buenavista massif, *Weston 5845* (MO, NY). **San José/Cartago Border:** Cordillera de Talamanca, vicinity of Cerro Asunción, ca. 20.6 mi beyond El Empalme, *Almeda & Wilbur 1605* (DUKE, F); Cordillera de Talamanca, ca. 7 km NW of Villa Mills in vicinity of Cerro de la Muerte, *Almeda 2710* (CR, MO); ca. 35.4 km SSE of El Empalme off the Interamerican Highway, Cordillera de Talamanca, *Almeda et al. 3381* (CAS, CR, F, GH, INB, K, MBM, MEXU, MO); ca. 28 km SSE of the La Cima turnoff from the Interamerican Hwy. on slopes of Cerro Sákira, Cordillera de Talamanca, *Almeda & Wilbur 3426** (CAS, CR, INB, K, MO, MBM, NY); Cordillera de Talamanca ca. 35 km SE of El Empalme and ca. 11 km NE of Villa Mills, *Almeda et al. 4251* (CAS); just below the highest point on the Interamerican Highway, NW of La Asunción, *Burger & Baker 9518* (F, MO); near Asunción at the summit of the Interamerican Hwy., *Burger & Gentry 8541* (F); Cerro Buena Vista, Cerro de la Muerte, Panamerican highway, Cordillera de Talamanca, *Fosberg 27316* (NY); Cerro de la Muerte, *Liesner & Heithaus 241* (MO); Asunción (summit of Cerro de la Muerte) 83 km from San José on the Pan American Highway, *Mori & Anderson 207* (F); edge of the páramo ca. 2 mi NW from La Asunción on the Carretera Interamericana towards El Empalme, *Wilbur & Almeda 17391* (DUKE, F); ca. 2 km SE of La Georgina and 8.3 km SE of La Asunción along the Carretera Interamericana, *Wilbur 21192* (CAS, DUKE); slopes of Cerro Sákira at the Páramo Buenavista, *Wilbur et al. 23754* (DUKE, F); on the upper slopes of Cerro Zacatales ca. 1 km NW of Asunción, the high point on the Interamerican Highway, *Wilbur et al. 23994* (DUKE, F); in the vicinity of Páramo Jaboncillo ca. 84 km on the Carretera Interamericana, *Wilbur 32416* (DUKE, MO). **Unknown location:** Páramo de Abejonal, *Pittier 2278* (G); Páramo de Abejonal, *Tonduz 7823* (BR[2], G); Cuesta de Tarrazu, *Tonduz 7867* (P).

4. Chaetolepis gentianoides (Naudin) Jacq.-Fél., Bull. Mus. Nat. Hist. Nat., B, Adansonia, sér. 4, 16(2–4):272. 1995. (**Figs. 6 g–i; 13**). *Nerophila gentianoides* Naudin, Ann. Sci. Nat. Bot., sér. 3, 14:120. 1850. Type: SENEGAL: swamps along the rivers of Senegambia, *Heudelot 668* (HOLOTYPE: P, internet image!; ISOTYPES: DS!, K!; P[2], internet images!).

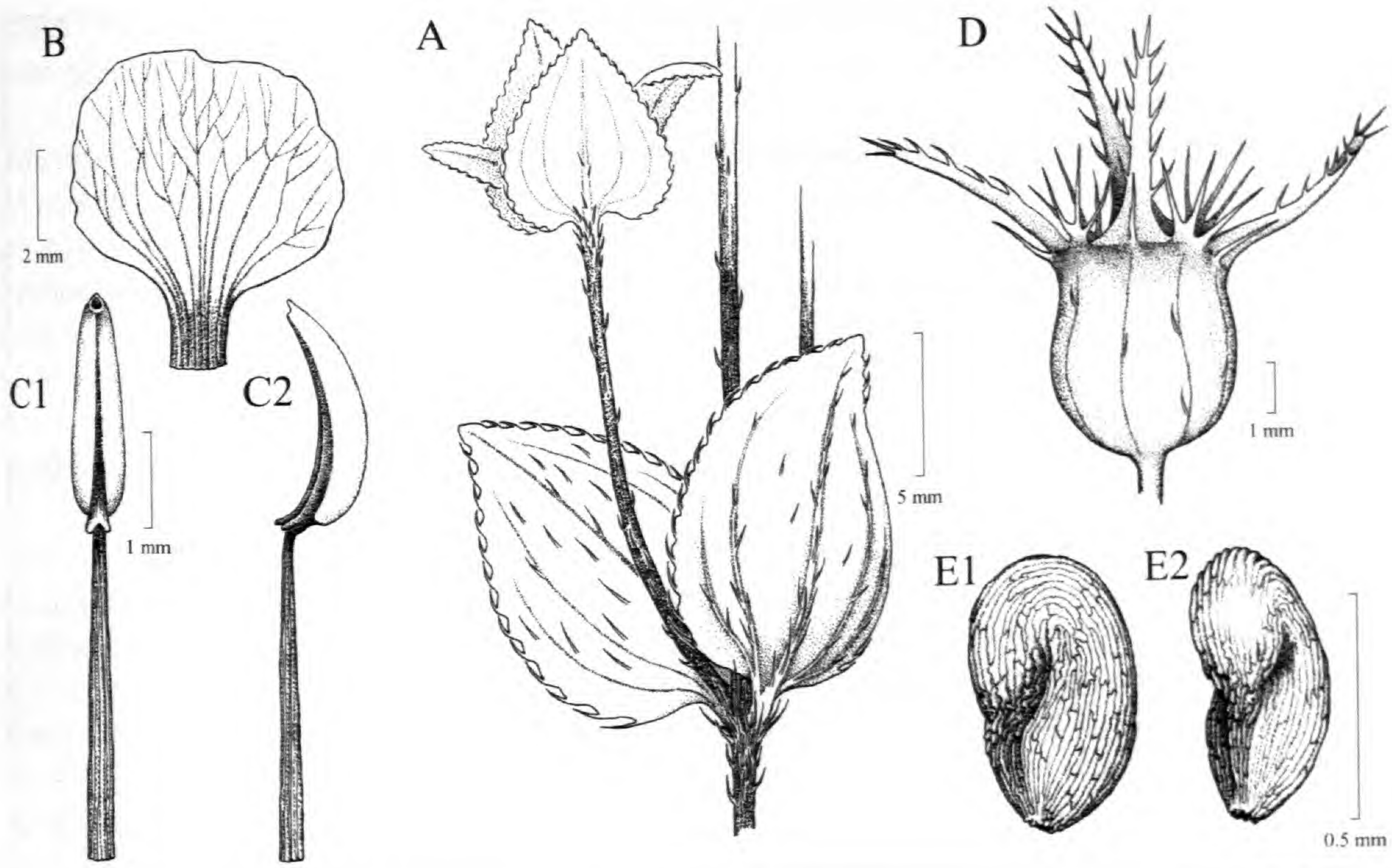


FIG. 13. *Chaetolepis gentianoides*. **A.** Habit. **B.** Petal (adaxial surface). **C1.** Stamen, dorsal view. **C2.** Stamen, profile view. **D.** Hypanthium. **E1.** Seed, profile view. **E2.** Seed, ventral view (A–E2 from *Jacques-Félix 235*, P).

Erect, moderately to compactly branched, annual herb 10–40 cm tall. Distal cauline internodes quadrate and sparsely to moderately covered with appressed, smooth eglandular trichomes 1 mm long. Distal cauline nodes with spreading, smooth, eglandular trichomes 1.5–2 mm long. Stems sparsely covered basally with antrorsely spreading, smooth eglandular trichomes 0.5–1.0 mm long. Principal leaves membranaceous; adaxial surface sparsely to moderately covered with minute, smooth eglandular trichomes that are antrorsely spreading and evenly distributed over the entire surface; abaxial surface moderately strigose with minute smooth eglandular trichomes on the primary and secondary veins, sparsely covered with the same trichomes between the higher order veins; blades 5–20 × 4–7 mm, ovate to elliptic, apex acute, base ranging from acute to cuneate or rounded, (3)-5-nerved, with one (sometimes two) pairs of secondary veins arising at the base; margins ciliate-crenulate; subsessile or with petioles 1 mm long, sparingly beset with smooth trichomes abaxially. Inflorescence terminal, flowers typically solitary but sometimes paired or borne in a simple 3-flowered dichasium. Bracts similar to primary leaves. Bracteoles 3.5–11 × 1–1.5 mm, linear, oblanceolate to narrowly obovate, 3-nerved, basally and apically acute, sessile; both surfaces sparsely pubescent on the actual surface and on the primary and secondary veins. Flowers subsessile or with pedicels 0.5–1.1 mm long, glabrous to minutely strigillose. Hypanthia (at anthesis) 2.5–4 × 2–3 mm, campanulate, sparsely to moderately covered with spreading, smooth eglandular trichomes 0.5–0.8 mm long; hypanthia (at maturity) with prominent vascular ribs when dry. Calyx lobes 1.5–2.6 × 0.8–1.2 mm, erect (sometimes spreading), narrowly triangular, apically acute; calyx lobes with smooth eglandular trichomes near the base; margins ciliate; intercalycine lobe sinus with a stalked, bifurcate or trifurcate trichome (stipitate-stellate, fide Wurdack, 1986). Petals 2–5 × 5–8 mm, yellow, apically obtuse and tipped with a terminal trichome, glabrous, entire. Filaments 2–5 mm long, yellow; anthers 2–3 × 0.5 mm, yellow, linear or somewhat arcuate; pore dorsally inclined; connective prolonged 0.2–0.4 mm below the thecae. Ovary sparsely covered apically with smooth eglandular trichomes; style 4–6 mm long, yellow, glabrous. Seeds 0.4–0.6 mm long, light brown. Chromosome number: $n = 9$.

Flowering.—November through March.

Habitat and Distribution (Fig. 14).—This species has been collected in West Africa from Senegal, Guinea-Bissau, Guinea, Sierra Leone, and the Ivory Coast at 1700–2100 m where it is restricted to wet, boggy areas along rivers or streams.

Discussion.—Jacques-Félix (1995) transferred *Nerophila gentianoides* to *Chaetolepis* based on vegetative, floral, and seed characteristics. Morphological evidence presented here tentatively confirms his decision despite differences in seeds, habit, and geography. *Chaetolepis gentianoides* shares many characters with the neotropical species including 4-merous flowers, yellow petals, ventrally unappendaged isomorphic anthers, trichome morphology, 4-locular ovaries, and a chromosome number of $n = 9$ (Favarger 1962; Bolkhovskikh et al. 1969). *Chaetolepis gentianoides* also has a consistent nested position in all phylogenetic reconstructions of the genus in the second analysis using morphological data. It has not been possible to study this species in the field. DNA sequences will surely provide the decisive data set to evaluate the relationships and generic disposition of this species.

Chaetolepis gentianoides is distinguished from other congeners by its herbaceous annual habit, stalked and branching trichomes at the intercalycine lobe sinuses (Fig. 13D), and the convex elongate periclinal cell walls of the seed testa (Fig. 6 g–i). All other taxa of *Chaetolepis* have more or less interdigitating compressed/flattened periclinal cell walls (Figs. 5 & 6).

Among congeners, *Chaetolepis phelpsiae* seems most closely related to *C. gentianoides* based on the strict consensus tree generated in this study and on their similar morphological characters. They both have dorsally inclined anther pores, yellow petals, ovate leaves, ciliate-crenulate leaf margins, and smooth eglandular trichomes on the hypanthia, both leaf surfaces, cauline nodes and internodes.

Chaetolepis phelpsiae differs from *C. gentianoides* by its perennial woody habit, abaxial leaf surface that is punctate with eglandular and glandular trichomes, forked trichomes between the calyx lobes; and calyx lobes with sessile glands intermixed with eglandular and glandular trichomes.

Additional specimens examined: **GUINEA:** Dalaba, *Chevalier 34349* (P); Timbo, *Chevalier 18430* (G); Kindia, *Farmar 214* (BM, K); Kindia, *Jacques-Félix 235* (P); Benna, *Jacques-Félix 7152* (P); Labe: Village of Vers Seriba, *Jacques-Georges 8071* (MO); Labe, *Roberty 6507* (G); location unknown, collector not given *16249* (K); Kala, collector not given *7376* (K). **GUINEA BISSAU:** Mangel near Dalaba, *Adames 401* (K); Boe, *Pereira 3017* (G); Boe, between Medina and Dandum, collector not given *2892* (K, P); Labe, collector not given *51519* (K); Faoual – Kakoni, collector not given *51248* (K). **IVORY COAST:** *Sindou et al.1131* (MO). **SIERRA LEONE:** Kabala, Mt. Loma, *Jacques-Georges 176* (MO); summit of Bintimane Peak at 6390 ft, *T.S. Jones 101* (K); Bintimane Peak, *Jones 83* (K); Loma Mountains below Bintimane, *J.K. Morton 392* (K); Bumban, *Morton 2915* (K).

5. Chaetolepis lindeniana (Naudin) Triana, Trans. Linn. Soc. London 28:51. 1871. (**Figs. 5 d–f; 15**). *Haplodesmium lindenianum* Naudin, Ann. Sci. Nat. Bot., ser. 3, 14:150, pl. 5, fig 4. 1850. TYPE: VENEZUELA: in the Andes near Trujillo and Mérida, *Linden 402* (HOLOTYPE: P!, photos: F!, GH!, NY!; ISOTYPES: BM!, BR![2], F!, G!, GH!, K![2], MA, internet image!, MPU, internet image!).

Trimeranthus alpestris Karsten, Linnaea 30:159. 1859. *Chaetolepis alpestris* (Karsten) Triana, Trans. Linn. Soc. London 28:51. 1871. Syn. nov. TYPE: VENEZUELA: in Boconó, Mérida, *Karsten s.n.* (HOLOTYPE: BM!; ISOTYPES: BR!; NY, internet image!).

Erect, much-branched shrub, 1–2.5 m tall. Distal cauline internodes quadrate, densely covered with trichomes 0.5–2 mm long that are tapered and sparsely roughened distally but thickened and greatly roughened at base (bulla-based). Distal cauline nodes with trichomes like those of the distal cauline internodes but broader basally and longer. Older branches woody, terete, exfoliating with age. Principal leaves coriaceous, densely covered with antrorsely spreading to appressed, bulla-based trichomes on the adaxial leaf surface; abaxial leaf surface densely covered with antrorsely spreading, barbellate trichomes on the primary and secondary veins like those of the distal cauline internodes; trichomes between the elevated primary and secondary veins like those on the primary and secondary veins but shorter; blades (3–)3.5–7(–9) × (1.5–)2.5–4.5 mm, ovate to elliptic-ovate, obtuse apically and basally (often broadly acute apically), 3-nerved; margins conspicuously revolute and fringed with bulla-based trichomes; petioles 1–1.5 × 0.5–0.7 mm, covered with trichomes like those of the nodes and internodes. Inflorescence terminal or axillary on lateral shoots, flowers solitary or in simple 3-flowered dichasia. Bracts identical to primary leaves. Bracteoles 3–5 × 2–3 mm, like the primary leaves but smaller. Floral pedicels 2–5 mm long, strigose like distal cauline internodes. Hypanthia (at anthesis) 2.5–3 × 2–2.5 mm,

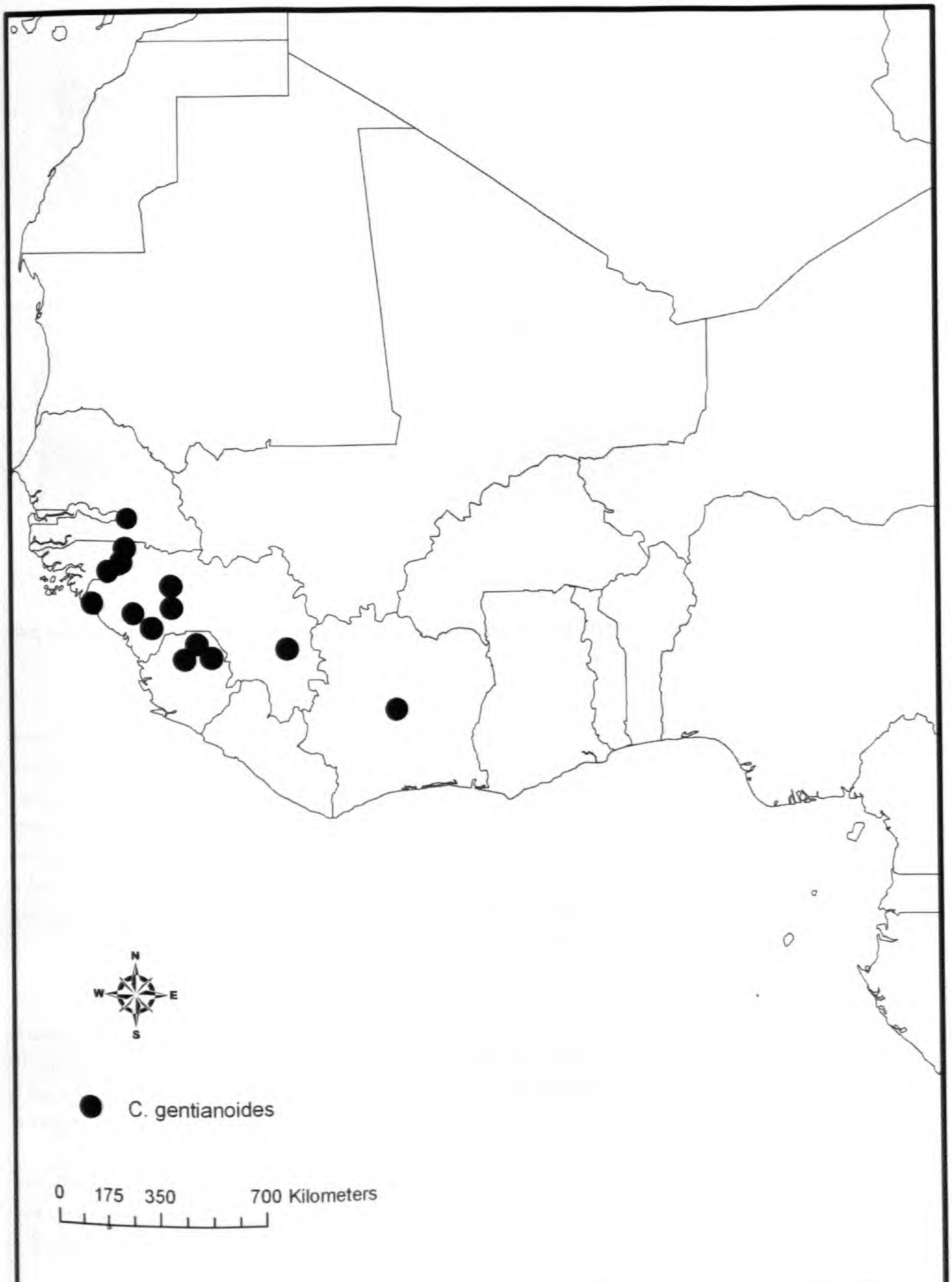


Fig. 14. Distribution of *Chaetolepis gentianoides*.

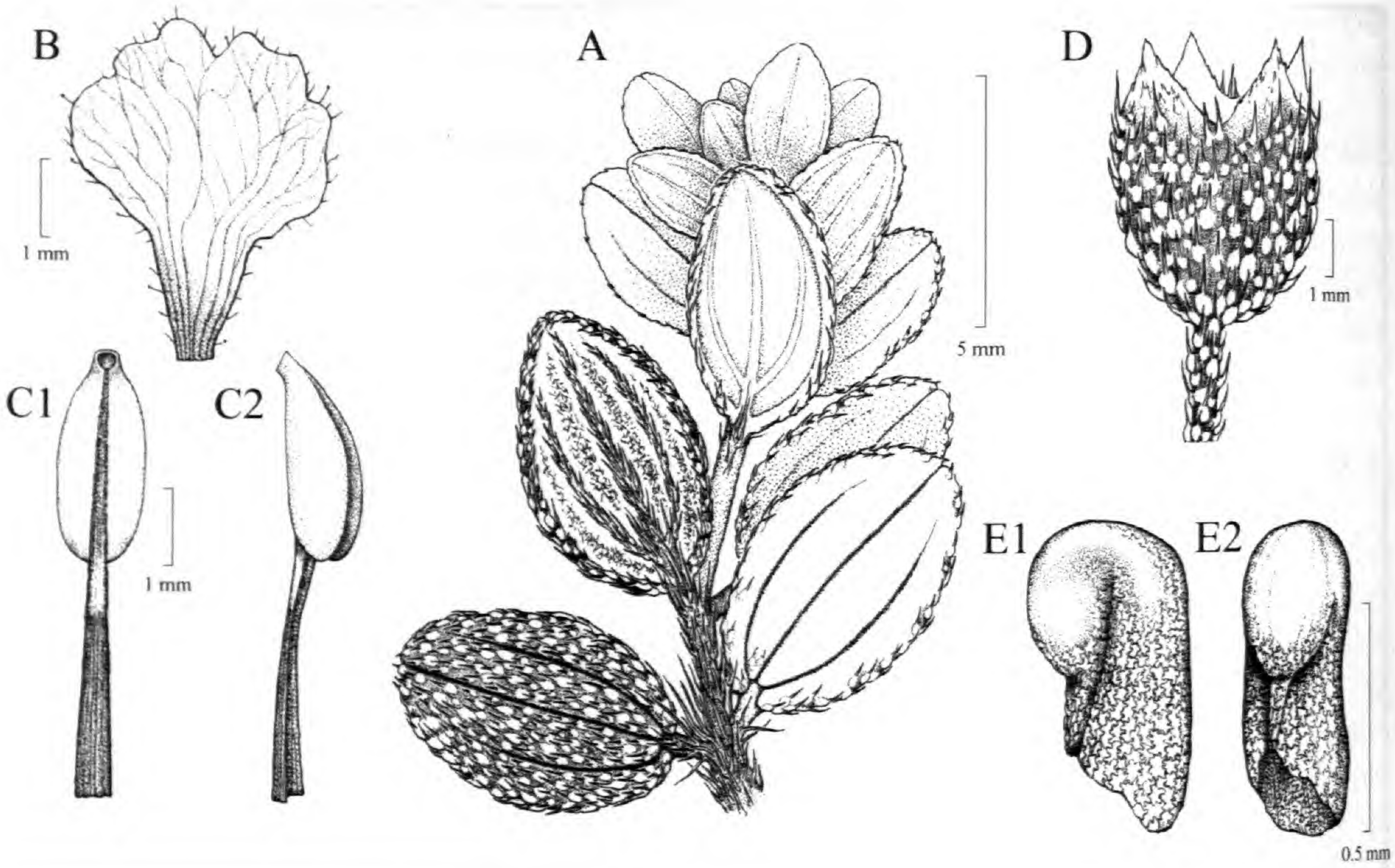


FIG. 15. *Chaetolepis lindeniana*. **A.** Habit. **B.** Petal (adaxial surface). **C1.** Stamen, dorsal view. **C2.** Stamen, profile view. **D.** Hypanthium. **E1.** Seed, profile view. **E2.** Seed, ventral view (A–E2 from *King et al. 10481*, F).

campanulate to subcampanulate, magenta, densely covered with antrorsely, appressed barbellate trichomes like distal cauline internodes, hypanthia (at maturity) with vascular ribs that are inconspicuous when dry; calyx lobes (on mature hypanthia) 1–1.5 × 0.8–1 mm, ascending, spreading, or reflexed, lance-deltoid, acute apically, ciliate; calyx lobes copiously strigose; intercalycine lobe sinus with one or several barbellate trichomes. Petals 5–6 × 2.5–4 mm, magenta, apex obtuse, margin fringed with trichomes. Filaments 3–4 mm long, dark magenta; anthers 1–1.5 × 0.4–0.6 mm, yellow, linear; pore dorsally inclined; connective not prolonged below the thecae. Ovary moderately to densely covered with roughened trichomes at the apex; style 7–8 mm long, magenta. Seeds 0.6–0.8 mm long, brown. Chromosome number: $n = 18$.

Flowering.—Throughout the year.

Habitat and Distribution (Fig. 16).—Known in Venezuela from the Cordillera de los Andes in Mérida, from Páramo Cupis to Páramo de Mucuchíes. It also ranges to Táchira in Páramo del Batallón and Páramo El Rosal. In Trujillo it occurs from Páramo Turmal to Páramo de Guaramacal. In Colombia it occurs along the Cordillera Oriental in the Department of Santander from Páramo de Berlín to Páramo de Mogotocoro and in several páramos in the Department of Norte de Santander north and east to Parque Nacional Natural Tamá and vicinity. Commonly collected along exposed roadsides and on rocky slopes in páramo at 2500–4000 m.

Discussion.—*Chaetolepis lindeniana* is a shrubby species distinguished by its elongate, basally roughened trichomes on cauline internodes and nodes, abaxial leaf surfaces, hypanthia, intercalycine sinuses, and calyx lobes. Other distinguishing features include bulla-based trichomes on the adaxial leaf surface (Fig. 15A), roughened trichomes on the ovary apex, and magenta petals with ciliate margins.

The closest relative of *Chaetolepis lindeniana* appears to be *C. santamartensis* based on the strict consensus tree generated in this study. Both species have roughened trichomes on the cauline internodes and nodes, abaxial leaf surfaces, hypanthium base, intercalycine sinuses, and calyx lobes. The two taxa also have entire cilia-ate leaf margins, magenta petals that are ciliate, and anthers with a dorsally inclined pore.

Chaetolepis santamartensis differs from *C. lindeniana* in having slightly roughened trichomes (vs. densely



FIG. 16. Distributions of *Chaetolepis lindeniana* and *C. loricarella*.

roughened trichomes) on the cauline internodes and nodes, both leaf surfaces, hypanthium base, intercalycine sinuses, and calyx lobes. Other differences seen in *Chaetolepis santamartensis* include glabrous primary and secondary abaxial leaf veins and smooth eglandular trichomes on the ovary apex.

Representative specimens examined: **COLOMBIA. Santander:** 3 km from El Picacho toll booth on road from Pamplona to Bucaramanga, *Almeda et al. 10630* (CAS, COL); Cordillera Oriental, Páramo de Santurbán, entre Bucaramanga y Berlín, *Barclay & Juajibioy 10428* (COL, MO); Cordillera Oriental, Páramo de las Vegas, entre Berlín y Las Vegas, *Barclay & Juajibioy 10452* (P); El Picacho, on road between Bucaramanga and Pamplona, *Barclay & Fernandez-Perez 3726* (COL, FMB); Pamplona, La Baja, *Funck & Schlim 1313* (P); Pamplona a Bucaramanga, Páramo de Berlín, *García-Barriga & Jaramillo 20000* (CAS, GH, P); Pamplona por Garcia, *Garganta 990* (US); Pamplona, *Kalbreyer 1193* (K); Páramo de Romeral, *Killip & Smith 8567* (GH, NY); edge of Páramo de Las Vegas, *Killip & Smith 15698* (GH, NY); mountains E of Las Vegas, *Killip & Smith 15801* (GH, NY); W slopes of Páramo Rico, *Killip & Smith 17229* (F, GH, NY); Páramo de Mogotocoro, near Vetas, *Killip & Smith 17651* (GH, NY); Páramo Rico, near Vetas, *Killip & Smith 17666* (GH, NY); Páramo de las Puentes, above La Baja, *Killip & Smith 18189* (GH, NY); de las Coloradas, above La Baja, *Killip & Smith 18403* (GH, NY); Carretera entre Bucaramanga y Pamplona, *Murillo & Jaramillo Mejia 1245* (COL, P); Municipio Charta, carretera hacia el Roble, *Orozco et al. 1600* (COL); Pamplona, collector unknown s.n. (K); Entre el corregimiento de Vetas y el Alto del Picacho, *Villamizar D14* (COL). **Norte de Santander:** Cordillera Oriental, Chorreon de Comageuta, entre Alto de Almorzadero y Quebrada de Presidente, *Barriga 10034* (F, NY); Hoya de Musticua, vertiente este (de Pamplona a Mutiscua), *Barriga & Cuatrecasas 10264* (F, NY); Municipio de Cácota, La Laguna, *Contreras et al. 43* (HECASA); entre Pamplona y Berlín, margen izquierda carretera, *Cuatrecasas & Rodriguez 27912* (COL, F, G, K, NY, P); Pamplona, por Garcia (sur de la ciudad), *Fábrega 990* (F); Cucutilla, Vereda Carrizal, Páramo El Romeral, *Galván et al. SYG1025* (COL); E slope of Páramo de Santurbán, toward Mutiscua, *Killip & Smith 19596* (GH, NY); Municipio de Cucutilla, vereda El Carrizal, Páramo de El Romeral en limites con Santander, *Sanchez et al. 5088* (COL, HECASA); Herrán, Tamá, Sector Orocue, 7°25'31"N, 72°26'38"W, *Mendoza et al. 7252* (FMB, HECASA); Municipio de Pamplona, Cerro del Río Pamplonita, *Sánchez & Solano 4862* (HECASA); Municipio de Chitagá, Páramo del Almorzadero, sector de Presidente, *Sánchez et al. 10383* (HECASA); Provincia de Pamplona, páramos de la baja, *Schlim 1739* (BR). **Unknown location:** *Jeuxei 850800* (BR). **VENEZUELA. Lara:** Municipio Moran, trail from Humo-caro to Buenas Aires (Caserío) below Páramo Los Rosas, *Liesner et al. 8030* (MO); between Buenos Aires and Páramo de las Rosas, *Steyermark 55483* (F, NY). **Mérida:** 6.4 km SE of Laguna Mucubají off the road to Barinas, *King et al. 10481* (CAS, F); Sierra Nevada above Mérida, *Alston 6843* (BM, NY); near Laguna Negra, Páramo de Mucuchíes, *Alston 6937* (BM, NY); Laguna Mucubají and Laguna La Negra, *Aristeguieta 2453* (F, NY); Páramo de Mucuchíes, distrito Rangel, *Aymard & Ortega 1349* (CAS); distrito Miranda, entre Laguna Mucubají y Laguna La Negra, *Badillo 5543* (F); slightly below La Laguna Negra, on trail to La Laguna de Mucubají, *Barclay & Juajibioy 9799* (MO); Páramo de Conejos, *Bernardi 680* (G, K, NY); Páramo Laguna Negra, Mucubají, entre Laguna Grande et Laguna Negra, *Bernardi 10793* (G, K, MO, NY); Páramo de la Negra, *Bernardi 10838* (F, G, K, NY); Ibid., *Bernardi et al. 16962* (K); Santo Domingo, *Bogner 829* (K, M); 67 km NE of Mérida along road to Barinas, *Breteler 3346* (G, NY, P); near Chachopo, *Bruijn 1025* (MO, US); distrito Rangel, Páramo de Mucuchíes, ascending from Hotel Los Frailes to the base of Picocha El Gavilon, *Carpenter & Joyal 880* (NY); Piñango, hoya del Río Chirurí, *Cuatrecasas et al. 28042* (F, G, K, NY); Sierra Nevada de Mérida, Páramo en La Quebradita, *Cuatrecasas 28104* (GH); entre Pueblo Nuevo y el Páramo de Quirorá, Las Tapias, *Cuatrecasas et al. 28474* (F); Laguna Negra, Sierra de Santo Domingo, *Dennis 2050* (K); distrito Rangel. Páramo de Santo Domingo, near Hotel Los Frailes, Parque Nacional Sierra Nevada, *Dorr & Barnett 5182* (CAS, NY); distrito Rangel, la cuenca del Río Los Granates, west and east banks of the Río Los Granates, Parque Nacional Sierra Nevada, *Dorr & Barnett 5577* (NY, P); distrito Libertador, Loma Redonda, Laguna Los Anteojos, *Fernández 441* (MO); Sierra Nevada de Santo Domingo, Loma del Baho alrededores de la Laguna de Valencia, cercanías de Santo Domingo, *Figueiras 8733* (CAS); *Funck & Schlim 864* (BM, BR [4], P); Páramo de Partahuelo, *Funck & Schlim 1266* (BM, P); Carretera Andina, Páramo de La Negra, *Garcia-Barriga 13301* (NY); Quebrada de Saisay, *Gehriger 37* (GH, F, MO, NY); Lugana Negra, *Gines 1732* (NY); E of the moranine systems of Laguna Victoria, along Hwy. 7, *Hanselmann & Loveless 27* (DUKE); Páramo de Conejos, *Hanbury-Tracy 111* (NY); Laguna Negra, *Hueck s.n.* (F); Sierra Nevada de Santo Domingo, versant NW Laguna Negra, *Humbert 26408* (NY, P); Ibid., *Jacquemoud 233022* (G); Páramo de San José, *Jeffrey et al. 2142* (K); trail leading from El Royal, between Las Escaleras y La Negrita, *Luteyn 6098* (CAS, NY); trail leading from La Negrita downstream towards Puente de La Escalera, *Luteyn 6167* (CAS, MO, NY); Pico Espejo, *Mägdefrau 650* (M); al norte de la carretera Mérida-Barinas, *Meier 1132* (M); Páramo de Santo Domino, Laguna Negra, *Moritz 1591* (CAS, K, P); El Valle, *Oberwinkler 13420* (M); Anden, El Rincon, *Oberwinkler 12397* (M); Quebrada de Saisay, *Pittier 37* (G); San Rafael de Mucuchíes, along river, *Pittier 12910* (G, NY); Páramo de Laguna Grande, *Pittier 13245* (F, G, K, NY); below Cañada Cerrada, *Pittier 13289* (F); distrito Rangel, Laguna Negra, *Quintero 127* (MO); distrito Libertador, Sierra Nevada de Mérida, alrededores de la Laguna Verde, al pie del Pico Humboldt, *Ruiz-Terán 2303* (DUKE); San Rafael, entre los caseríos de El Molino y El Portachuelo, Distrito Chacón, *Ruiz-Terán 3061* (P); alrededores de Laguna Azul o del Corazón, Páramo de los Granates, Sierra Nevada de Santo Domingo, distrito Rangel, *Ruiz-Terán 6356* (P); Páramo de Minugú, unos 10 km al SE de San Rafael de Mucuchíes, *Ruiz-Terán 7193* (BR, F); parte media del valle en U de La Mucuchache, al sur del Páramo de Apartaderos, Cordillera de los Andes, a orillas de la quebrada La Mucuchache, afluente del Río Chama, distrito Rangel, *Ruiz-Terán & López-Figueiras 289* (F, P); orillas de la quebrada de Piedras Blancas, unos 2 km al norte del Pico de Piedras Blancas, en la ruta hacia el sitio Los Caracoles, Cordillera de los Andes, distrito Justo Briceño, *Ruiz-Terán & López-Figueiras 348* (F, P); Páramo de San José abajo de la Piedra de Pirela, vertiente de Mucutuy, Cordillera de Los Andes, distrito Arzobispo Chacón, *Ruiz-Terán & López-Figueiras 727* (F, P); El Alto, Páramo de El Jabón, abajo de los limites del estado Trujillo, Cordillera de los Andes, *Ruiz-Terán & López-Figueiras 877* (P); Páramo de Mijará, Cordillera de los Andes, unos 15 km al NNE de la aldea Chacantá, municipio Libertad, distrito Arzobispo Chacón, *Ruiz-Terán & López-Figueiras 1506* (F, US); Páramo de Quirorá (o de Chacantá), Cordillera de los Andes, municipio Estanques, distrito Sucre, *Ruiz-Terán & López-Figueiras 1685* (MO); Páramo de Quirorá (o de Chacantá), Cordillera de los Andes, municipio Estanques, distrito Sucre, *Ruiz-Teran*

& Lopez-Figueiras 1717 (NY); distrito Rivas Dávila, Páramo de El Batallón, entre la torre de TV y Laguna Grande, *Ruiz-Terán & López-Figueiras* 8307 (DUKE); Filo de La Vagabunda, entre las poblaciones de El Morro y Aricagua, distrito Libertador, *Ruiz-Terán & López-Figueiras 9371* (MO); entre El Baramito y Las Porqueras, 7–10 km, al NE de la población de El Morro, vertiente suroccidental de la Sierra Nevada de Mérida, distrito Libertador, *Ruiz-Terán & López-Figueiras 9441* (MO); Sierra Nevada, Páramo de la Feirier, *Schlim 1738* (BR); Teleferico trail, Pico Espejo, between 2nd and 3rd station, *Smith 1196* (NY); Páramo de la Negra, *Smith & Jorgensen 3536* (F); between Timotes and Paramito, *Steyermark 55729* (F, NY); páramos between Chachopo and El Aguila, *Steyermark & Rabe 97183* (NY); above Mérida by teleferica station Loma Redonda, *Taylor 670* (K); en las cercanías de los arroyos y en las faldas abrigadas de Mucubají, *Tamayo 4353* (F); valley above La Hechicera Mérida, *Tanner & Kapos 118* (MO); Páramo de Conejos, *Tracy 111* (K); distrito Justo Briceño, near Almorzadero, along road, *van der Werff & Ortega 6148* (CAS, MO); above the city of Mérida, slopes of Pico Espejo, *Wolfe & Torres-Lesama 1296* (CAS); Páramo Cupis above San José, Distrito Arzobispo Chacón, *Wurdack et al. 2769* (US); Páramo La Culata, N of the upper Río Mucujun, *Zeeuw 9015* (NY); location unknown, *Simmons 287* (K); San Rafael de Mucuchíes, along river, *Zugegangen 12910* (M); below Cañada Cerrada, on wall along river, *Zugegangen 13289* (M); Ibid., *Zugegangen 469* (M). **Táchira:** Páramo Zumbador, *Charpin & Jacquemoud 13384* (F, G, K); Páramo del Batallón, Quebrada Ferruginosa, *Cuatrecasas et al. 28404* (F); trail leading to summit of Páramo de Tamá, *Luteyn et al. 5320* (CAS, NY); NNE slopes of Pata de Judío, *Luteyn et al. 5943* (CAS, F, NY); Páramo de Portachuelo, *Luteyn et al. 6021* (CAS, NY); distrito Uribante, 19–21 km SE of La Grita on road to San José de Bolívar, Páramo del Batallón-Páramo El Rosal area, *Luteyn & Lebron-Luteyn 9884* (CAS, MO, NY); laderas pantanosas al pie de peñascos de arenisca de Pata de Judío, entre Alto de Cruces y el páramo arriba de la Quebrada Teleférica, cerca de la frontera Colombia-Venezuela, *Steyermark & Dunsterville 101162* (G, NY); Páramo de Tamá, en la region calcárea, cerca de la frontera Colombia-Venezolana, *Steyermark & Dunsterville 98736* (M). **Trujillo:** La Morita, arriba de Jajó, *Aristeguieta & Medina 3467* (NY); distrito Boconó, Páramo de Guaramacal, 20 km al E de Boconó, *Aymard et al. 2922* (NY); NW slopes of La Reinosa, above La Mesa de Esnujaque, *Box & Alayon 3810* (BM); distrito Urdaneta, Páramo La Providencia, *Colella et al. 1212* (NY); distrito Carache, Páramo Turmal, SE of Pico Jabon, *Dorr et al. 5306* (CAS, NY); El Atajo, cabecera de la quebrada El Riecito, vertiente suroccidental del gran Páramo de La Cristalina, distrito Trujillo, *Ruiz-Teran 9002* (MO); entre Santa Rosalía y Cerro El Diablo, 0.5 km al este de Boconó, *Solé 20* (NY); cumbre del Páramo de Guaramacal, entre Boconó y Guaramacal, *Steyermark 104855* (NY).

6. Chaetolepis loricarella Triana, Trans Linn. Soc. London 28:51.1871 (**Fig. 17**). TYPE: COLOMBIA. Magdalena: Sierra Nevada de Santa Marta, *Purdie* s.n. (HOLOTYPE: BM?; ISOTYPE, K! [2]).

Erect, much-branched shrub to 1.2 m tall. Older internodes woody, terete, exfoliating with age. Distal cauline internodes terete and densely covered with appressed, narrowly lanceolate, flattened scales 0.5–0.75 × 0.25–0.5 mm that are basally attached with a raised thickening near the point of attachment, margins erose. Distal cauline nodes like internodes except scales slightly longer (0.75–1 mm). Principal leaves coriaceous, appressed-imbricate; adaxial surface glabrous apically, with a dense covering of minute appressed scales at the base of the blade; abaxial surface covered with two kinds of scales: apical region with narrow, elongate scales 1.5–2.5 × 0.5 mm adnate to the epidermis for their entire length, basal region beset with flattened erose scales like those of the upper cauline internodes; blades 3–5 × 1–2 mm, ovate to lanceolate, concave, tightly appressed with the abaxial side of the leaf facing outward and adaxial side facing inward toward the stem axis, apically acute, basally obtuse, with a single depressed vein visible only on the adaxial side; margins seemingly entire but minutely and obscurely erose and/or fringed with sessile or subsessile flattened scales with irregularly erose margins; sessile or with petioles 0.25–0.5 mm long, covered with flattened erose scales abaxially. Flowers terminal, solitary and sessile. Floral bracts like the principal leaves in shape and size, subsessile or sessile. Hypanthia (at anthesis) 2.5–3.5 × 1–2 mm, broadly cylindric to campanulate, densely covered with appressed scales like those of the distal internodes; hypanthia (at maturity) with ribs not evident when dry. Calyx lobes 1–1.5 × 0.3–0.5 mm, narrowly triangular, apically acute, margins ciliate, scales present at the base of the calyx lobes, glabrous toward the apex, persistent. Intercalycine lobe sinus usually with a single large scale. Petals 7–10 × 3–7 mm, magenta, apically obtuse, margins ciliate. Filaments 5–6 mm long, magenta; anthers yellow, linear-oblong, bilobed ventro-basally and with a single deflexed lobe 1–2 × 0.25–0.5 mm dorso-basally; connective prolonged 0.2–0.4 mm below the thecae; pore dorsally inclined. Ovary apex densely covered with scales. Style 8–11 mm long, magenta. Seeds 0.7–0.9 mm long, tan or light brown. Chromosome number: unknown.

Flowering.—May through July.

Habitat and Distribution (Fig. 16).—*Chaetolepis loricarella* is endemic to the Sierra Nevada de Santa Marta, Colombia at 2900–3700 m. Labels on available collections indicate that it occurs in grassy páramos and along stream beds.

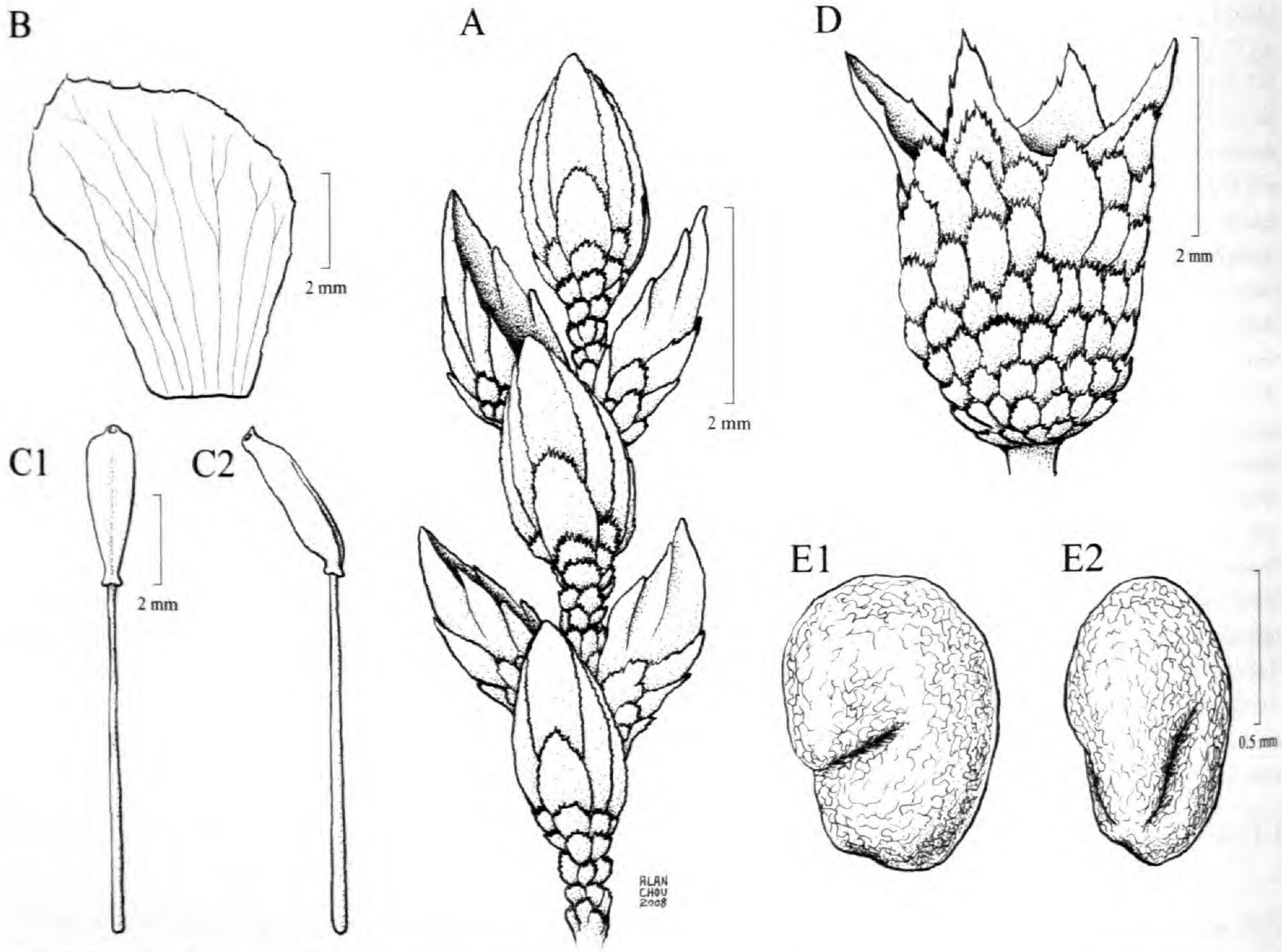


Fig. 17. *Chaetolepis loricarella*. A. Habit. B. Petal (adaxial surface). C1. Stamen, dorsal view. C2. Stamen, profile view. D. Hypanthium. E1. Seed, profile view. E2. Seed, ventral view (A–E2 from *Kernan 154*, NY).

Discussion.—*Chaetolepis loricarella* does not appear to have any close relatives. It has unusual trichomes that are modified into flattened scales (Fig. 17A, D). These are found on the cauline internodes and nodes, both leaf surfaces, and hypanthia. In addition, this species has roughened trichomes on the ovary apex, a single primary vein on the leaf blade, and concave, appressed, imbricate coriaceous leaves with the abaxial surface facing outward and exposed and the adaxial surface facing inward toward the stem and concealed.

Representative specimens examined: **COLOMBIA. César:** Valledupar, *Carbonó 3646* (COL, UTMC); Mpio. Pueblo Bello, Village Nabusimake, first big ridge above the valley between Nabusimake and Pantano, in direction of Duitama, *Stancik 893* (COL). **Magdalena:** Sierra Nevada de Santa Marta, *Funck 393* (BR, P); Andredua, headwaters of Río Aracataca, *Kernan 154* (COL, NY, US); N slope of Cuchilla Cinturuagaca, next valley up from that of the Río Duriameina, *White & Alverson 638* (COL, MO).

7. Chaetolepis microphylla (Bonpl.) Miq., Comm. Phyt. 72. 1840. (**Figs. 5 g–i; 19**). *Rhexia microphylla* Bonpl., Rhex. 4, pl. 2. 1806–1808. *Osbeckia microphylla* (Bonpl.) DC, Prodr. 3:140. 1828. TYPE: COLOMBIA or VENEZUELA: *Bonpland s.n.* (HOLOTYPE: P!; ISOTYPE: COL, internet image!).

Erect, compactly branched subshrub 10–50 cm tall. Distal cauline internodes quadrate, densely covered with elongate, moderately barbellate trichomes 0.5–1 mm long and smooth eglandular trichomes 1–2 mm long. Older branches woody, terete, glabrous or sparsely covered with moderately barbellate trichomes. Principal leaves coriaceous, somewhat unequal in each pair; adaxial leaf surface moderately covered with antrorsely spreading to appressed, moderately barbellate trichomes 0.1–0.5 mm long; abaxial leaf surface densely covered on and between primary and secondary veins with spreading or antrorsely spreading barbellate and dendritic trichomes 0.1–0.5 mm long with short or well-developed axes and a moderate number of spreading terete arms; blades 2–6 × 2–4 mm, ovate, rhombic, or rhombic-orbicular, acute (sometimes rounded or obtuse)

apically, cuneate to attenuate basally, adaxial surface with three nerves that extend for the entire length of the blade, sometimes 5-nerved with the outer pair arising from the base of the blade and extending one third to one half the length of the blade before converging with the margin; margins entire, sometimes revolute, ciliate; petioles 1–1.5 × 0.5 mm, glabrous. Inflorescence terminal, flowers solitary or borne in a simple 3-flowered dichasium. Bracteoles 2.5–5 × 2–3.5 mm, ovate, rhombic, elliptic, or obovate, indument of the adaxial surfaces like that of the principal leaves except for a glabrous basal region, indument of the abaxial surface identical to principal leaves, 3-nerved, petioles 0.5–1 mm long. Floral pedicels 0.5–1 mm long, moderately to densely covered with antrorsely spreading, moderately barbellate trichomes. Hypanthia (at anthesis) 2–3 × 2–3 mm, suburceolate to cylindric, glabrous or sometimes sparsely beset distally with moderately barbellate trichomes on the vascular ribs; hypanthia (at maturity) with vascular ribs somewhat conspicuous on drying. Calyx lobes 1.5–2 × 1–1.5 mm, erect or ascending, lance-deltoid, apically acute, ciliate, beset with moderately roughened trichomes adjacent to the midrib but not along the margins; intercalycine lobe sinus with 1–3 smooth eglandular trichomes. Petals 2.5 × 2 mm, yellow, entire, apically obtuse with a single terminal barbellate trichome, margins glabrous. Filaments 2.5–3.5 mm long, pale brown when dry; anthers 0.2 × 0.4–0.6 mm, yellow, linear; pore ventrally inclined; connective prolonged 0.2–0.3 mm below the thecae. Ovary apex moderately to densely covered with smooth eglandular trichomes; style 0.5–0.6 mm long. Seeds 0.4–0.6 mm long, brown. Chromosome number: $n = 9$.

Flowering.—Throughout the year.

Habitat and Distribution (Fig. 19).—In Colombia this species is largely centered in the Cordillera Oriental (Boyacá, Cundinamarca, Norte de Santander, and Santander) with outliers in the Cordillera Central (Antioquia) and Cordillera Occidental (Cauca). In Venezuela it ranges from the state of Mérida west to Táchira. It occurs between 2000–3700 m.

Discussion.—*Chaetolepis microphylla* is readily recognized by its small leaf blades and its elongate moderately roughened trichomes on the cauline internodes, nodes, both foliar surfaces, and midrib of the calyx lobes.

Chaetolepis microphylla is most similar to *Chaetolepis santamartensis* based on morphological similarities and their positions on the consensus trees (Fig. 2). These species share entire, ciliate leaf margins, and roughened trichomes on the cauline internodes and nodes, both foliar surfaces, and midrib of the calyx lobes (Fig. 18).

Chaetolepis santamartensis differs from *C. microphylla* in having slightly roughened trichomes on the cauline internodes and nodes, both foliar surfaces, hypanthium base, intercalycine sinuses and calyx lobes, five (vs. three) elevated veins on the abaxial leaf surface; magenta, ciliate petals (vs. yellow and eciliate); and a dorsally inclined (vs. ventrally) anther pore.

Representative specimens examined: **COLOMBIA. Antioquia:** Municipio de Yarumal, Llanos de Cuivá, *Acevedo et al. 1400* (COL); Municipio de Yarumal, Llanos de Cuivá, sobre la carretera al cemeterio, *Callejas et al. 2560* (NY); San Pedro, *Daniel 1341* (F); Municipio de Santa Rosa, *Lozano et al. 5988* (COL); Municipio de Entrerríos, ca. 3 km from Entrerríos on the road to Santa Rosa de Osos, downstream from bridge along banks of Río Grande, *MacDougal & Roldan 3640* (CAS); highland of Santa Rosa, *unknown collector 7542* (F, GH); en una meseta a 1 km al norte de Santa Rosa de Osos, *Valderrama et al. s.n.* (NY); Municipio San Pedro, km 4 of road San Pedro-Entrerríos, along roadside, *Zarucchi 5865* (COL, MO); Highlands of Santa Rosa, collector unknown *7549* (K). **Boyacá:** Arcabuco, via Arcabuco-Villa de Leyva, *Alonso JLF14181* (COL); Raquira, *Castroviejo 10585* (MO); Carretera Raquira *Cleef et al. 3459* (COL); Páramo de La Rusia, NW-N de Duitama, *Cleef 7040* (COL); Municipio de Ramiriqui, *Fagua 399* (COL); Desierto de La Candelaria, cerros alrededor del Convento, *García-Barriga 20247* (COL, F, GH); Laguna Seca, beyond Alto del Oso, *Grubb et al. 580* (COL, K); 2 or 3 km al nordeste de Villa de Leyva, *Melampy 23* (FMB); Villa de Leyva. Subiendo por la montaña arriba del Hotel Duruelo, *Mendoza 1153* (FMB); Paipa, Piscinas Municipales de Aguas Termales, Lomita arriba de piscinas, *Silverstone-Sopkin 5423* (NY); Municipio Samaca, Vereda Ruchal-parte alta, *Stancik* 1308 (FMB); Cómbita, vereda de Santa Bárbara, *Uribe-Uribe 6609* (NY); between Ubaté and Cucunubá, 5°16'8.9"N, 73°47'52.33"W, *Wood 3699* (FMB). **Boyacá/Santander border:** 1 km beyond La Palma on road between La Palma and Gámbita, *Almeda et al. 10496* (CAS, COL). **Cauca:** Cerro California, Cordillera Occidental, *Becking & Negret BN271* (COL). **Cundinamarca:** Boqueron de Bogotá, *Andre 736* (NY); Ibid., *Arbeláez 605* (CAS); Zipaquirá, *Arbeláez & Castañeda 1331* (NY); Bogotá, *Ariste-Joseph s.n.* (GH, NY, US); Páramo de Guasca, *Balls 5686* (BM, K); Bogotá, quebrada Chicó, *Black 46-405* (F); Cerro de Guadalupe, *Barclay 4089* (COL); Macizo de Bogotá, quebrada de Chicó, *Cuatrecasas 5009* (NY); Cerros de Bogotá, *Daniel 1452* (F); Cerro de Monserrate, *Duque-Jaramillo 2870* (COL, NY); Páramo de la Calera, *Fernandez 2418* (BM); mouth of San Francisco Canyon, lower slopes of Cerro de Guadalupe, Bogotá, *Fosberg 22166* (NY); Ibid., *Funck & Schlim 1259* (P); Cordillera Oriental, Macizo de Bogotá, Guadalupe, *Garcia 113* (NY); Municipio Guasca, Páramo de Guasca, *Garcia-Barriga 6223* (COL, NY); Bogotá, *Goudot s.n.* (P); Road Sopó-Guasca, 6 km SE of Sopó, *Grabandt & Huertas 20* (US); Guasca, *Grant 7368* (GH); Bogotá, *Hartweg 1000* (BM, BR [2]); Monserrate, Bogotá,

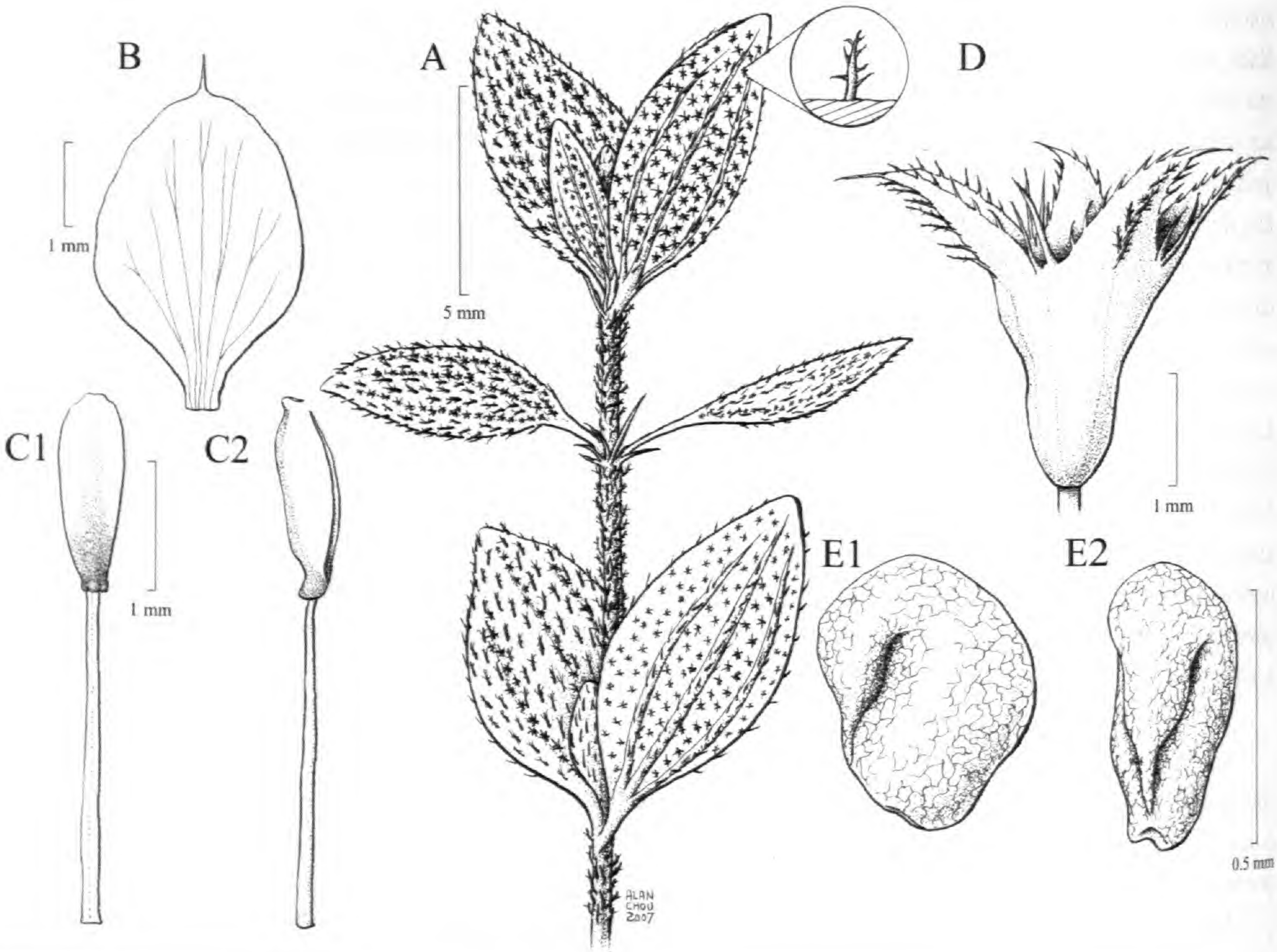


Fig. 18. *Chaetolepis microphylla*. A. Habit. B. Petal (adaxial surface). C1. Stamen, dorsal view. C2. Stamen, profile view. D. Hypanthium. E1. Seed, profile view. E2. Seed, ventral view (A–E2 from *Daniel 1341*, F),

Haught 4986 (K, NY); Guadalupe, Bogotá, *Haught 5654* (US); Vitelme, *Hermann 11350* (NY); Bogotá, *Holton 26* (NY); Bogotá, *Holton 920* (GH); Municipio de Fómeque, Páramo de Chingaza, *Huertas & Camargo 6489* (COL); montes, el Retiro-Chicó, cerca de Bogotá, *Jaramillo 3478* (NY); Bogotá, *Kalbreyer 818* (K); Bogotá, lomas sobre la calle 53, *Lozano s.n.* (COL); *Linden 694* (BM, K, NY, P); Andes de Bogotá, *Meayor 74* (BR); above Bogotá, *Rusby & Pennell 1285* (GH, MO, NY); Julia Hill, Sabana de Bogotá, *Schiefer 576* (CAS, GH); Macizo de Bogotá, Cerro El Retiro, *Schultes 7075* (F, K); Macizo de Bogotá, quebrada Chicó near the city of Bogotá, *Schultes & Villarreal 7089* (NY); mountains above Bogotá, *Sprague 213* (K); Bogotá, *Triana s.n.* (BR, NY); Bogotá, *unknown collector 057* (MO); Tocancipá, montes altos al oriente, *Uribe-Uribe 5999* (COL, MO, NY); hills near Bogotá, *Wier 192* (K); Bogotá, *Wier s. n.* (BR); Ubaté, *Wood* 3699 (K); location unknown, *Wood 3510* (FMB, K); Bogotá, páramos in via ad Calera, *Woronow & Juzepczuk 5106* (NY). **Norte de Santander:** Municipio de Cácota, La Laguna, *Contreras et al. 79* (HECASA); vertiente oriental, Pamplona, cerro al NE, *Cuatrecasas & Garcia-Barriga 10209* (COL); Alrededores de Pamplona, *Fábrega 666* (F); Pamplona, alto de las Coronadas, al sur de la ciudad, *Fábrega 1293* (F); Sierra, *Humbert 26732* (P); Municipio de Mutiscua, Vereda San José del Pino, *Sánchez & Vargas 10580* (HECASA). **Santander:** Proyecto Parque Nacional Natural Yariguíes, San Vicente de Chucurí, *Ardila 121* (FMB); Páramo del Almorzadero, region media, *Cuatrecasas 9944* (F); Pamplona a Sabaneta, camino de Cucutilla, *Fábrega 752* (F); vicinity of California, *Killip & Smith 16769* (GH, NY); vicinity of La Baja, *Killip & Smith 17118* (F, GH, MO, NY); municipio de Onzaga, Vereda Chaguacá, *Orozco et al. 1912* (NY). **VENEZUELA. Mérida:** Páramo de San José abajo de la Piedra de Pirela, vertiente de Mucutuy, Cordillera de los Andes, distrito Arzobispo Chacón, *Ruiz-Terán & López-Figueiras 720* (F); Carretera Estanques-El Molino, 55 km de Estanques, *Michelangeli et al. 1268* (CAS, NY); Municipio de Onzaga, Vereda Chaguacá, *Torres et al. 486* (COL); distrito Arzobispo Chacón, in páramo between San José and Mucutuy, *Wurdack et al. 2773* (F, MO, NY, P, US). **Táchira:** Páramo-Zumbador, 14 km S of El Cobre, *Gentry 11081* (MO); Los Mirtos, entre El Cobre y El Zumbador, al Borde de la Carretera, distrito Jáuregui, *Ruiz-Terán et al. 8105* (F); subpáramo, 2 kms de Zumbador, entre Zumbador y Queniquea, *Steyermark 105092* (DUKE, P); entre Boca de Monte y Zumbador, *Steyermark & Rabe 96837* (NY); 2 kms de Zumbador, entre Zumbador y Queniquea, *Steyermark 105092* (F, NY). **Unknown location:** *Linden s.n.* (BR).

8. Chaetolepis perijensis Wurdack var. **perijensis,** Phytologia 8:166. 1962. (**Figs. 20 A–D1, E1, E2**). TYPE: COLOMBIA. MAGDALENA: collected in páramo between Cerro Venado and Cerro Avion, Sierra de Perijá, 3270–3350 m, 8 Nov 1959, *J. Cuatrecasas & R.R. Castaneda, 25118* (HOLOTYPE: US, internet image!; ISOTYPE: COL, internet image!).

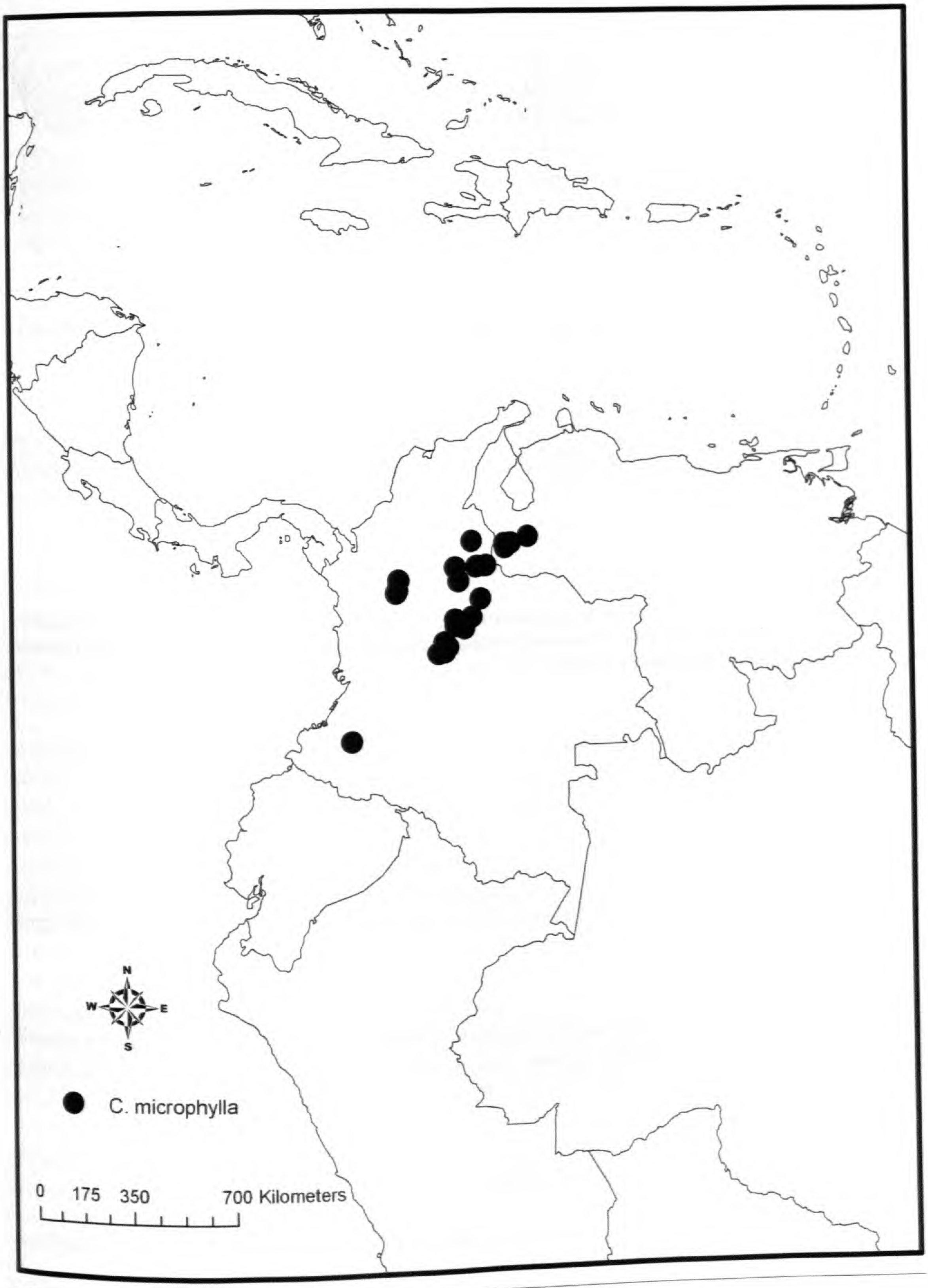


Fig. 19. Distribution of *Chaetolepis microphylla*.

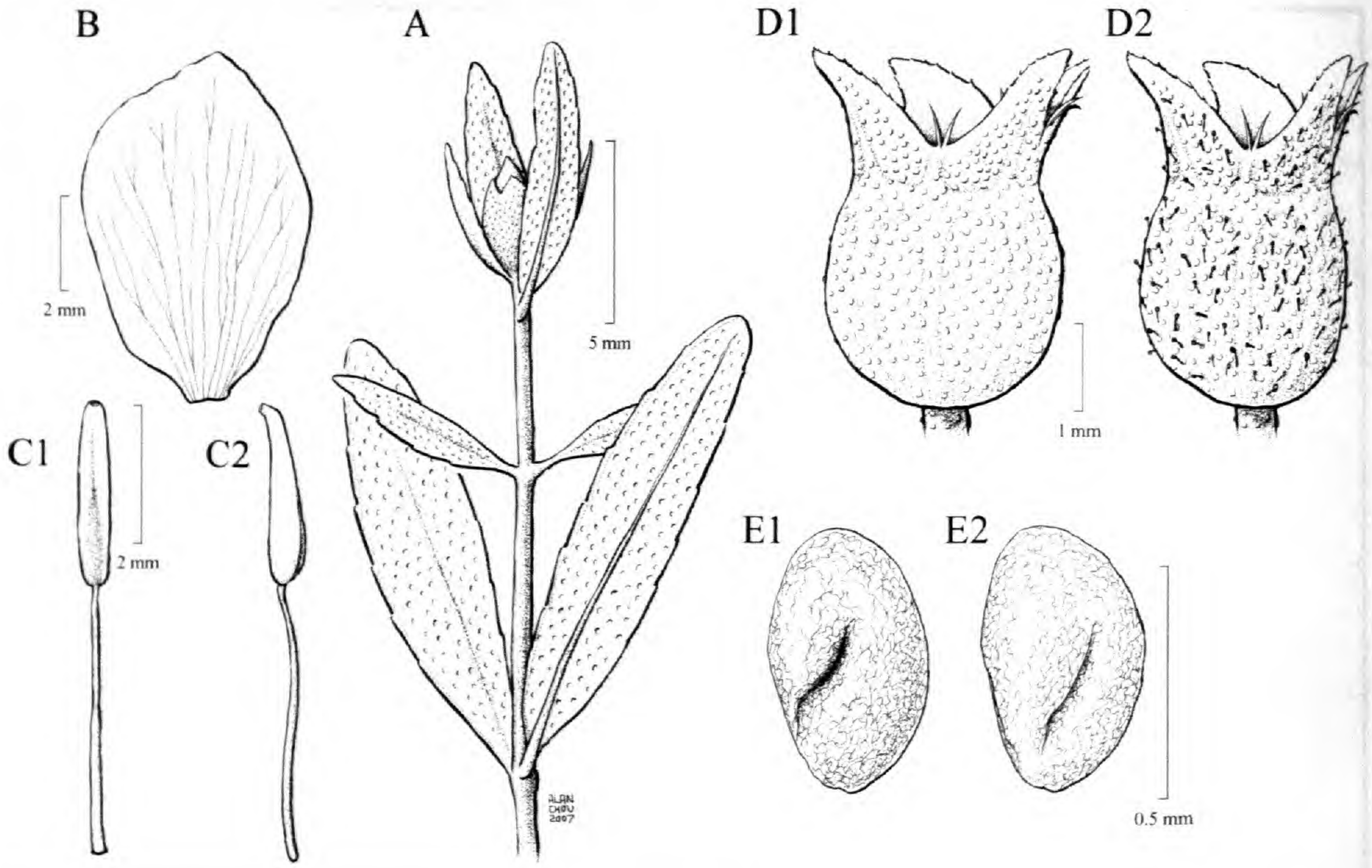


Fig. 20. ***Chaetolepis perijensis*** **var.** ***perijensis*****. A. Habit. B. Petal (adaxial surface). C1. Stamen (dorsal view). C2. Stamen (profile view). D1. Hypanthium. E1. Seed (profile view). E2. Seed (ventral view).** ***Chaetolepis perijensis*** **var.** ***glandulosa*****. D2. Hypanthium (A, B, C1, C2, D1, E1, E2 from,** ***Cuatrecasas & Castaneda, 25082*****, US; D2 from** ***Tillett & Hönig 747-946*****, US).**

Erect, densely branched, spreading subshrub up to 40 cm tall. Distal cauline internodes and nodes quadrate, winged, beset with sessile glands and appearing minutely furfuraceous when dry. Older stems terete, exfoliating with age. Principal leaves coriaceous, spreading, adaxial and abaxial surfaces covered with sessile glands; blades 5–8 × 1–1.5 mm, oblong, rounded apically, broadly acute basally, 1-nerved; margins obscurely ciliolate-serrulate, the cilia 0.1–0.2 mm long, appressed and often caducous; petioles 0.5–1.5 × 0.25 mm, glabrous. Flowers terminal, often on lateral branches, solitary; bracts 3.5–4.5 × 0.5–1 mm, similar to principal leaves but smaller; petioles 0.3–0.8 × 0.1–0.2 mm, glabrous. Floral pedicels 0.25–0.5 mm long, beset with sessile glands and appearing minutely furfuraceous when dry. Hypanthia (at anthesis) 3–4 × 3–4 mm, urceolate, beset with sessile glands and appearing minutely and caducously furfuraceous when dry; hypanthia (at maturity) with conspicuous vascular ribs when dry. Calyx lobes 1–1.5 × 0.75–1 mm, erect, deltoid, apically acute, ciliate, covered with sessile glands and a minutely furfuraceous indument when dry; intercalycine lobe sinus usually with one smooth, minute eglandular trichome. Petals 4.5–6 × 2.5–3.5 mm, yellow, entire, glabrous, acute to obtuse apically and lacking a terminal trichome. Filaments 2–3 mm long, yellow; anthers 2–2.5 × 0.5 mm, yellow, linear; pore dorsally inclined; connective prolonged 0.1–0.2 mm below the thecae. Ovary apex sparsely to moderately covered with smooth eglandular trichomes. Style 5–7 mm long, brownish. Seeds 0.4–0.5 mm long, pale brown. Chromosome number: unknown.

Flowering.—November through February.

Habitat and Distribution (Fig. 21).—Endemic to páramo in the Sierra de Perijá of César and Magdalena departments, Colombia at 3000–3350 m.

Discussion.—*Chaetolepis perijensis* var. *perijensis* is distinguished by its furfuraceous cauline internodes and nodes that are both furfuraceous and with sessile glands. The leaf blades are oblong with one primary vein, abaxially punctate, and entire.

The closest relative of *Chaetolepis perijensis* var. *perijensis* appears to be *C. alpina*. These taxa both have

sessile glands on the hypanthium, adaxial leaf surface, cauline internodes, and calyx lobes. Both taxa also share a punctate abaxial leaf surface, a ciliate leaf margin, smooth eglandular trichomes on the intercalycine sinuses and ovary apex, and anther pores that are dorsally inclined.

Chaetolepis alpina is unlike *C. perijensis* var *perijensis* in having ovate, 3-nerved leaf blades, crenulate leaf margins, and the elevated primary vein on the abaxial leaf surface beset with sessile glands and smooth eglandular trichomes. In addition, the cauline nodes have smooth eglandular trichomes and lack glands altogether.

Representative specimens examined: **COLOMBIA. César:** Serranía de Perijá, Municipio Manaure, Cerro del Avión, en Páramo Levantamientos, *Rangel et al. 11181* (COL); Serranía del Perijá, Municipio Manaure, Casa de Vidrio, *Rangel et al. 11007* (COL). Magdalena: Sierra de Perijá, E of Manaure, Sabana Rubia, páramo, 3000–3100 m, *Cuatrecasas & Castaneda 25082* (COL, US); Sierra de Perijá, ENE of Manaure, páramo, 1km from the Venezuelan border, 3000 m, *Grant 10870* (US).

9. Chaetolepis perijensis Wurdack var. **glandulosa**, Wurdack, Phytologia 41:1. 1978. (**Fig. 20 D2**). TYPE: VENEZUELA. ZULIA: Distrito Perijá, 5 km N of Buena Vista, at the base of cliffs along the international boundary from Hacienda Buena Vista to the N side of Cerro Laminado to the headwaters of Río Apon; Sierra de Perijá, Serranía de Valledupar, 3300–3650 m, 9–10 Jul 1974, *S.S. Tillett & K.W. Hönig 747-946* (HOLOTYPE: US!).

Erect, much branched subshrub to 30 cm tall. Distal cauline internodes quadrangular, winged, glabrous or minutely furfuraceous and sparsely covered with stalked glandular trichomes and sessile glands. Older branches woody, the bark furrowed with age. Principal leaves coriaceous and spreading; adaxial leaf surface minutely furfuraceous and with sessile glands when dry; abaxial leaf surface glandular-punctate; blades 4–7.5 × 1–1.5 mm, oblong, obtuse to rounded apically, obtuse or broadly acute basally, the single primary nerve extending the entire length of the blade; margins obscurely ciliolate-serrulate, the cilia 0.1–0.2 mm long, appressed and often caducous; petioles 0.3–0.8 × 0.4–0.5 mm, glabrous. Flowers terminal and solitary, often on lateral branches. Bracts 3–4 × 0.6–1 mm, similar to principal leaves but smaller, petioles 0.5–1 × 0.4–0.5 mm, glabrous. Floral pedicels 0.6–1.0 mm long. Hypanthia (at anthesis) 3–4 × 2.5–3 mm, urceolate to narrowly campanulate, moderately to densely covered with sessile glands, appearing somewhat minutely furfuraceous when dry and moderately covered with glandular trichomes; hypanthia (at maturity) with vascular ribs conspicuous when dry. Calyx lobes 0.8–1.2 × 0.9–1.1 mm, erect, lance-triangular to deltoid, acute apically, margins ciliate; calyx lobes glandular and appearing minutely furfuraceous when dry; intercalycine lobe sinus with a single eglandular trichome. Petals 4–5 × 2–3 mm, yellow, entire, glabrous, apex acute to obtuse and lacking a terminal trichome. Filaments 3–4 mm long, yellow; anthers 1.5–2 × 0.25–0.5 mm, linear; pore dorsally inclined; connective prolonged 0.1–0.2 mm below the thecae. Ovary apex sparsely to moderately covered with smooth eglandular trichomes; style 9–10 mm long, yellow to magenta. Seeds 0.7–1 mm long, brown. Chromosome number: unknown.

Flowering.—July.

Habitat and Distribution (Fig. 21).—Known only from the type locality where it occurs in areas with sparse, low lying vegetation, on rocks and cliff bases at 3300–3650 m.

Discussion.—The holotype was the only collection available for study so no critical assessment of its taxonomic status is possible. This variety differs from the nominate one by its hypanthial indument (Fig. 20 D2) and geographic distribution. *Chaetolepis perijensis* var. *glandulosa* has hypanthia with sessile glands intermixed with smooth glandular trichomes while *C. perijensis* var. *perijensis* has a hypanthium with only sessile glands. Both varieties occur on the Sierra de Perijá which extends along the northeastern border of Colombia and Venezuela, but *Chaetolepis perijensis* var. *glandulosa* is found at 3300–3650 m and the nominate variety grows at 3000–3350 m. Further study of these populations is needed to determine whether the above mentioned differences are consistent and worthy of formal taxonomic recognition.

10. Chaetolepis phelpsiae Gleason var. **phelpsiae,** Brittonia. 7:82.1950. (**Figs. 22 A–D1; E1, E2**). TYPE: VENEZUELA. AMAZONAS: Cerro Yavi, elev. 1400 m, 1–3 Mar 1947, *K.D. Phelps & C.B. Hitchcock 27* (HOLOTYPE: NY!).

Compactly branched subshrub 10–30 cm tall. Distal cauline internodes quadrate, somewhat winged, sparsely covered with spreading, glandular and eglandular trichomes 1–1.5 mm long. Cauline nodes similar to internodes but with a moderate to dense covering of eglandular trichomes 1–2 mm long. Older internodes terete,

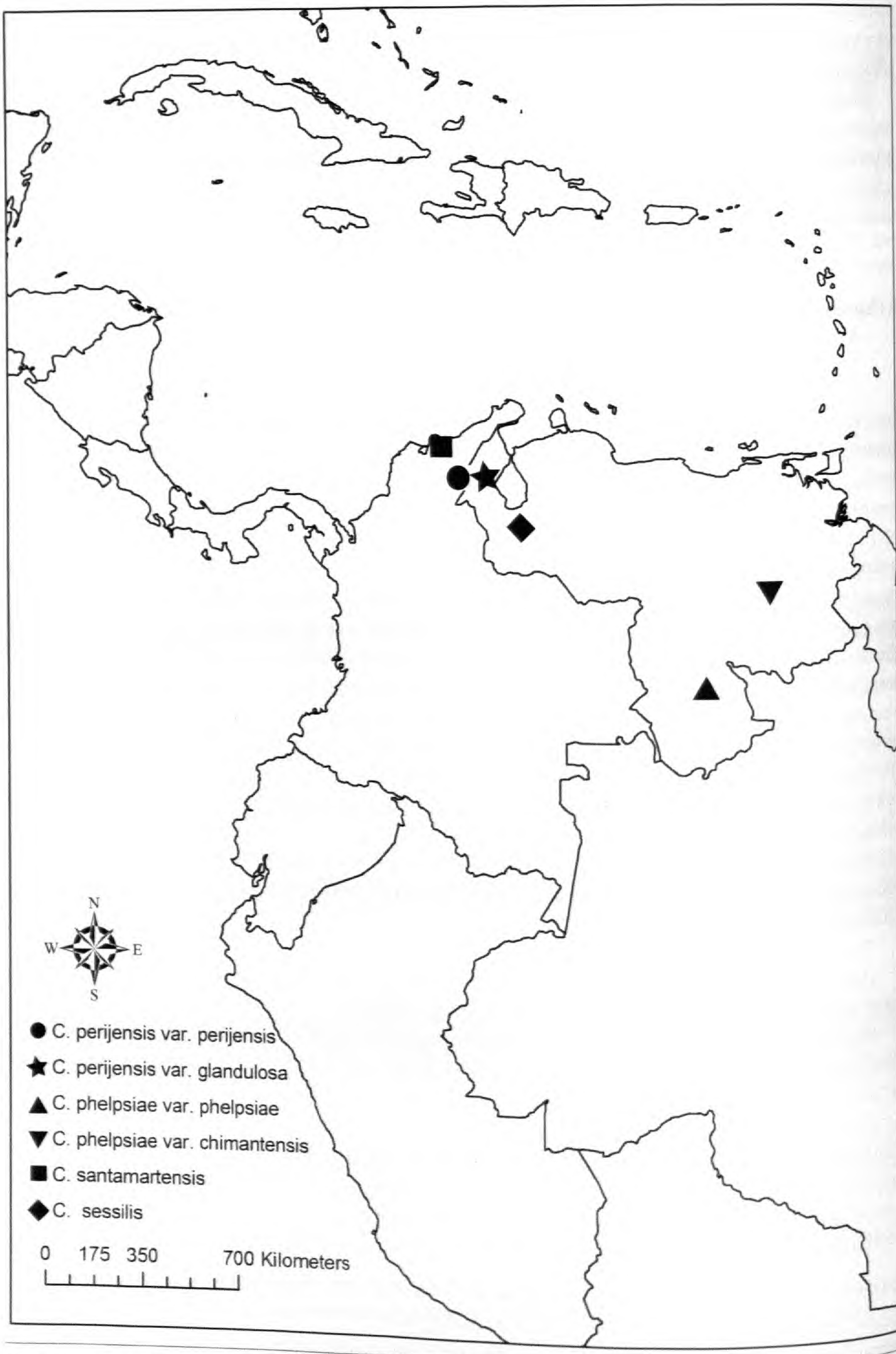


FIG. 21. Distributions of *Chaetolepis perijensis* var. *perijensis*, *C. perijensis* var. *glandulosa*, *C. phelpsiae* var. *phelpsiae*, *C. phelpsiae* var. *chimantensis*, *C. santamartensis*, and *C. sessilis*.

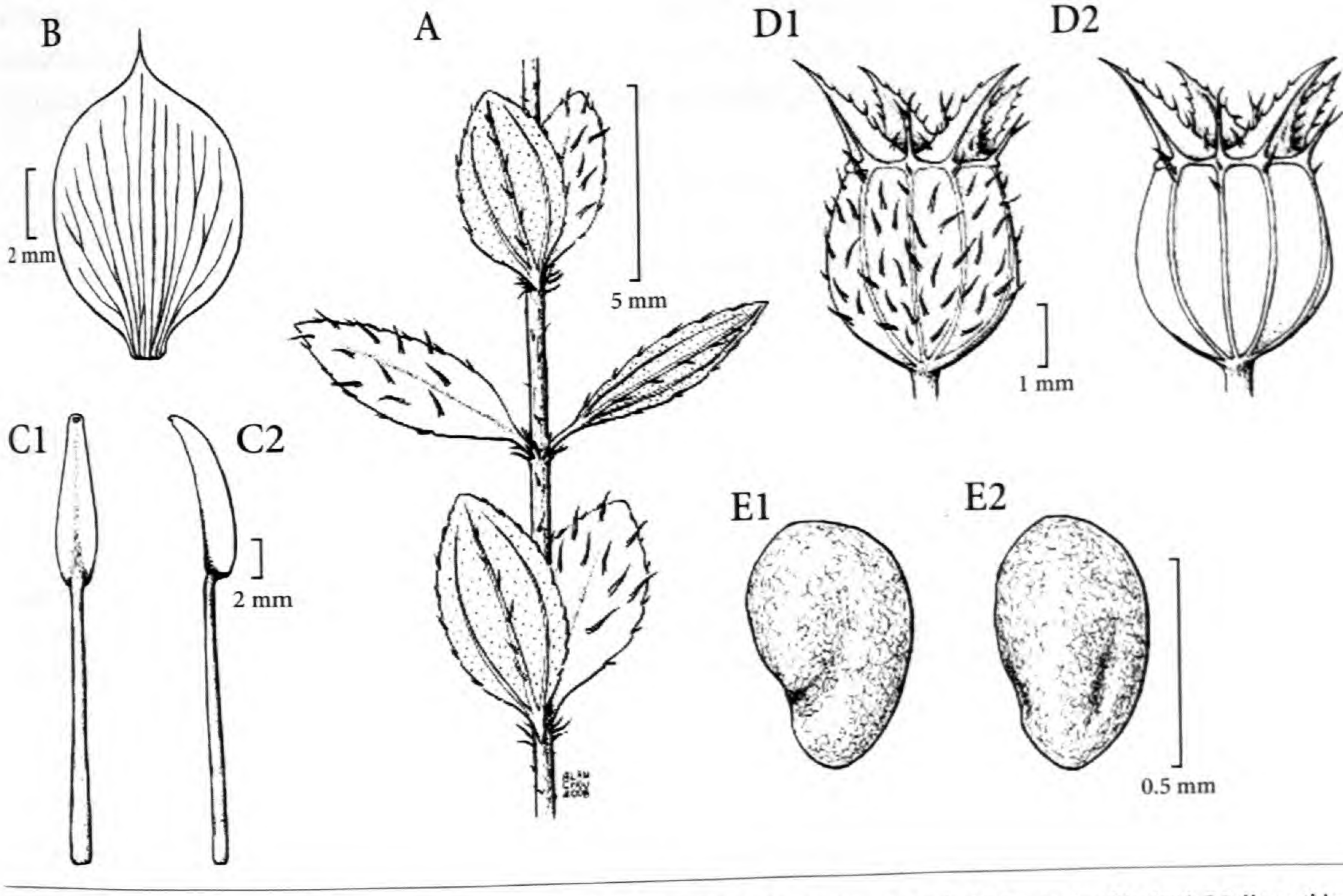


FIG. 22. *Chaetolepis phelpsiae* var. *phelpsiae*. **A.** Habit. **B.** Petal (adaxial surface). **C1.** Stamen (dorsal view). **C2.** Stamen (profile view). **D1.** Hypanthium. **E1.** Seed (profile view). **E2.** Seed (ventral view). *Chaetolepis phelpsiae* var. *chimantensis*. **D2.** Hypanthium (A, B, C1, C2, D1, E1, E2 from *Phelps & Hitchcock* 6, NY; D2 from, *Wurdack 521*, F, NY, US).

woody, glabrous, exfoliating with age. Principal leaves coriaceous and spreading; adaxial surface sparsely to moderately covered with antrorsely spreading, eglandular trichomes on the upper two-thirds of the blade, sometimes glabrous; abaxial surface glandular-punctate and also sparsely covered with glandular and eglandular trichomes between the primary and secondary veins, sparsely beset with eglandular and glandular trichomes on the primaries and secondaries; blades 7–15 × 2–5.5 mm, lanceolate to ovate, acute apically, cuneate basally, 3–5-nerved with three innermost nerves extending the entire length of the blade and the outermost pair extending a third to half the length of the blade; margins ciliate-crenulate; petioles 1.5–2.5 mm long, sparsely to moderately covered with eglandular trichomes. Flowers terminal, solitary or in simple 3-flowered dichasia. Bracts 4.5–9 × 1.5–3.5 mm, like the principal leaves but smaller; petioles 0.5–1 × 0.3–0.4 mm. Floral pedicels 0.25–0.5 mm long, glabrous. Hypanthia (at anthesis) 3–4 × 2–3 mm, campanulate to suburceolate, moderately covered with somewhat appressed or spreading, smooth eglandular trichomes; hypanthia (at maturity) with vascular ribs prominent when dry. Calyx lobes 2–2.5 × 1–1.5 mm, erect or ascending, narrowly deltoid, apically acute, ciliate, beset with sessile glands and a sparse cover of smooth eglandular trichomes and smooth glandular trichomes; intercalycine lobe sinus with a bifurcate trichome, sometimes also with one or two smooth eglandular unbranched trichomes 1–2 mm long. Petals 5–8 × 4–5 mm, yellow, margins entire, glabrous, apex cuspidate with a terminal trichome. Filaments 5–6.5 mm long, yellow; anthers 4–5 × 0.3–0.5 mm, yellow, linear to arcuate; pore dorsally inclined; connective minutely prolonged below the thecae 0.2–0.3 mm. Ovary apex moderately covered with smooth eglandular trichomes; style 7–12 mm long, yellow. Seeds 0.4–0.6 mm long, pale brown. Chromosome number: unknown.

Flowering.—March.

Habitat and Distribution (Fig. 21).—Known only from Cerro Yavi in Amazonas state, Venezuela, on rocks and sandstone cliffs at 1400–1900 m.

Discussion.—Chaetolepis phelpsiae var *phelpsiae* is a much branched subshrub with smooth eglandular

and glandular trichomes that cover the abaxial leaf surfaces and cauline internodes. This variety is readily distinguished by its ciliate-crenulate leaf margin, punctate abaxial leaf surface, forked trichome on the intercalycine sinuses, and calyx lobes with sessile glands, smooth eglandular trichomes and smooth glandular trichomes.

Chaetolepis phelpsiae var. *phelpsiae* most closely resembles *C. anisandra*. These two taxa have anther pores that are dorsally inclined, and an ovary apex with smooth eglandular trichomes. These species also share ovate leaves with cuneate bases; leaf margins that are cilate-crenulate; and smooth eglandular trichomes on the distal hypanthial area, both leaf surfaces, cauline nodes, and internodes.

Chaetolepis anisandra differs from *C. phelpsiae* var. *phelpsiae* in having a glabrous hypanthial base; cauline internodes that are densely covered with a mixture of smooth eglandular and glandular trichomes; and calyx lobes that are glabrous. It consistently occurs at higher elevations (2100–3400 m) than *C. phelpsiae* in northern South America.

Representative specimen examined: **VENEZUELA. Amazonas:** Cerro Yavi, *Phelps & Hitchcock 6* (NY).

11. Chaetolepis phelpsiae Gleason var. **chimantensis** (Wurdack) Grimm & Almeda, stat. nov. (**Fig. 22 D2**).

Chaetolepis phelpsiae Gleason ssp. *chimantensis* Wurdack, Mem. New York Bot. Gard. 10(5):138. 1964. TYPE: VENEZUELA. BOLÍVAR: Chimantá Massif, frequent along lower escarpment face of Sarven-tepui, elev. 1900–2050 m, 13 Jan 1953, *J.J. Wurdack 34108* (HOLOTYPE: US!; ISOTYPES: GH, K!, NY, P!, U, internet image!).

Much-branched subshrub 10–30 cm tall. Distal cauline internodes quadrangular, slightly winged, sparsely covered with spreading glandular and eglandular trichomes 0.5–0.7 mm long. Distal cauline nodes like internodes except moderately to densely covered with smooth eglandular trichomes 0.5–1 mm long. Older internodes terete, woody, glabrous and exfoliating with age. Principal leaves coriaceous, somewhat unequal in size in each pair, spreading; adaxially sparsely covered with spreading, smooth eglandular trichomes or glabrous; abaxially punctate between the primary and secondary veins and with a sparse cover of glandular and eglandular trichomes on the actual surface; primary and secondary veins with glandular and eglandular trichomes; blades 7–16 × 4–11 mm, ovate, elliptic-ovate to orbicular-ovate, acute apically, cuneate basally, with three or five elevated veins abaxially (three that extend the entire length of the blade and two that arise at the base and extend for one third to one half the length of the blade); margins ciliate-crenulate; petioles 0.5–2.5 mm long, sparsely covered with smooth eglandular or glandular trichomes. Flowers terminal, solitary or borne in a simple 3-flowered dichasium, bracts and bracteoles 6–10 × 3–4.5 mm, like principal leaves but smaller in size. Floral pedicels 0.5–1 mm long, glabrous. Hypanthium (at anthesis) 3.5–5 × 2.5–4 mm, urceolate, upper half sparsely covered with scattered appressed or spreading, smooth eglandular (sometimes glandular) trichomes, lower half glabrous; hypanthia (at maturity) with vascular ribs prominent and conspicuous when dry. Calyx lobes 2–2.5 × 1–1.5 mm, deltoid to lance-triangular, apically acute, erect or spreading, ciliate, beset with sessile glands and a sparse cover of smooth glandular and eglandular trichomes both on and off the midrib, persistent; intercalycine lobe sinus with a forked trichome. Petals 7–10 × 4–5 mm, yellow, margins entire, glabrous, apex cuspidate with a terminal trichome. Filaments 7–9 mm long, yellow; anthers 2.5–3 × 0.4–0.5 mm, yellow, linear to arcuate; pore dorsally inclined, connective prolonged 0.2–0.3 mm below the thecae. Ovary apex sparsely to moderately covered with smooth eglandular trichomes; style yellow, 10–15 mm long. Seeds 0.5–0.6 mm long, pale brown. Chromosome number: unknown.

Flowering.—January through March.

Habitat and Distribution (Fig. 21).—*Chaetolepis phelpsiae* var. *chimantensis* is known only from eastern Venezuela on the Chimantá Massif at the upper falls of Río Tirica and the lower escarpment and talus forest of Sarven-tepui from 1900–2050 m.

Discussion.—Few collections of *Chaetolepis phelpsiae* var. *chimantensis* are known but it is readily distinguished from *C. phelpsiae* var. *phelpsiae* by several characters. A major portion of the hypanthium is glabrous while the apical region is sparsely beset with smooth eglandular trichomes (Fig. 22 D2). *Chaetolepis phelpsiae* var. *phelpsiae* has a hypanthium covered throughout with smooth eglandular trichomes. *Chaetolepis phelpsiae* var. *chimantensis* has ovate, 5-nerved leaf blades whereas *C. phelpsiae* var. *phelpsiae* has lanceolate leaf blades

that are 3-nerved. An evaluation of the differences between these varieties will be necessary when more and better material becomes available for study.

Representative specimens examined: **VENEZUELA. Bolívar:** vicinity of upper falls of Río Tirica above summit camp, *Wurdack 521* (F, NY, US).

12. Chaetolepis santamartensis Wurdack, Phytologia 8:165. 1962. (**Fig. 23**). TYPE: COLOMBIA. MAGDALENA: Sierra Nevada de Santa Marta, SE slopes, Hoya del Río Donachuí, near Col, 3070–3100 m, subpáramos, 9 Oct 1959 (fl, fr), *J. Cuatrecasas & R.R. Castaneda 24669* (HOLOTYPE: US!; ISOTYPE: COL, internet image!).

Erect, compactly branched shrub up to 2 m tall. Older internodes woody, terete. Distal cauline internodes quadrate and densely covered with spreading, elongate, slightly roughened trichomes 0.5–1.0 mm long. Principal leaves membranaceous and somewhat unequal in size in each pair; adaxial surface with antrorsely spreading, minutely roughened trichomes ca. 0.5 mm long evenly distributed over the entire surface; abaxial surface with erect, slightly roughened trichomes 0.4–0.8 mm long evenly distributed on and between the primary and secondary veins; blades 10–15 × 3–7 mm, ovate, elliptic to obovate, apex broadly acute to obtuse, base rounded, 5(–7)-plinerved with the three innermost nerves extending the entire length of the blade and the outermost pair extending one third to two thirds the length of the blade; margins entire to obscurely ciliate-crenulate; petioles 0.5–1.5 × 0.5 mm, densely covered with erect, slightly roughened trichomes. Flowers terminal, solitary or in simple 3-flowered dichasia. Bracts and bracteoles 4–6 × 3–4 mm, like principal leaves but smaller, petioles 0.4–0.6 × 0.2–0.3 mm. Flowers subsessile or on pedicels 1–2 mm long, densely covered with spreading, slightly roughened trichomes. Hypanthia (at anthesis) 3–4 × 3.5–4 mm, campanulate, moderately covered at the base with erect slightly roughened trichomes, upper two-thirds glabrous; hypanthia (at maturity) with vascular ribs only faintly visible when dry. Calyx lobes 1.5–2.5 × 2.5–3 mm, erect to spreading varying to reflexed, broadly deltoid, rounded apically, sparsely to moderately covered with erect slightly roughened trichomes, margins ciliate. Intercalycine lobe sinus with one to three barbellate trichomes. Petals 6–9 × 3–5 mm, magenta, margins ciliate and erose, apically obtuse. Filaments 4–6 mm long, magenta; anthers 2–3 × 0.5–0.8 mm, yellow, linear-oblong; pore slightly inclined dorsally. Connective not prolonged below thecae but with a single deflexed thickening dorso-basally. Ovary apex densely covered with slightly roughened trichomes; style 7–9 mm long, magenta, erect. Seeds 1 mm long, brown. Chromosome number: unknown.

Flowering.—October.

Habitat and Distribution (Fig. 21).—This species occurs on the southeastern slopes of the Sierra Nevada de Santa Marta of Colombia in Andean forests and subpáramos at 2500–3300 m.

Discussion.—Only five collections of *Chaetolepis santamartensis* are known but it is distinctive and readily recognized. It is a sizable shrub or subshrub with prevailingly 5-plinerved leaf blades and a copious indument of spreading roughened trichomes on uppermost internodes and on both leaf surfaces (Fig. 23).

Chaetolepis santamartensis shares some similarities with *C. microphylla*. Both species have entire ciliate leaf blades, compound dichasia, and roughened trichomes covering the internodes, nodes, and leaves.

Chaetolepis microphylla differs from *C. santamartensis* by its small ovate leaves (2–6 × 2–4 mm), glabrous hypanthial base, and elongate moderately roughened to dendritic trichomes covering the internodes, nodes and leaves. *Chaetolepis microphylla* has anthers with ventrally inclined (vs. slightly dorsally inclined) pores, leaves that have three veins that extend from the base of the blade to its apex, and yellow (vs. magenta) eciliate petals.

Representative specimens examined: **COLOMBIA. César:** Sierra Nevada de Santa Marta, Valledupar, páramo entre Mamancana y Nabusimake, *Carbonó 3657* (UTMC). **Magdalena:** Sierra Nevada de Santa Marta, valle del Río Donachuí, *van der Hammen 1156* (COL); Sierra Nevada de Santa Marta, transecto del Alto Río Buritaca, *Jaramillo et al. 5434* (COL); Sierra Nevada de Santa Marta, Alto Buritaca, *Rangel & Cleef 908* (COL).

13. Chaetolepis sessilis Pittier, J. Wash. Acad. Sci. 13:385. 1923. (**Fig. 24**). TYPE: VENEZUELA. MÉRIDA: Páramo de Aricagua, 3200 m, 31 Mar 1922, *A. Jahn 1037* (HOLOTYPE: VEN, internet image!; ISOTYPES: G!, GH!, NY!, US).

Compactly branched subshrub 20–30 cm tall. Distal cauline internodes subquadrate, winged or carinate, sparsely to moderately covered with sessile glands. Distal cauline nodes like internodes but sparsely covered

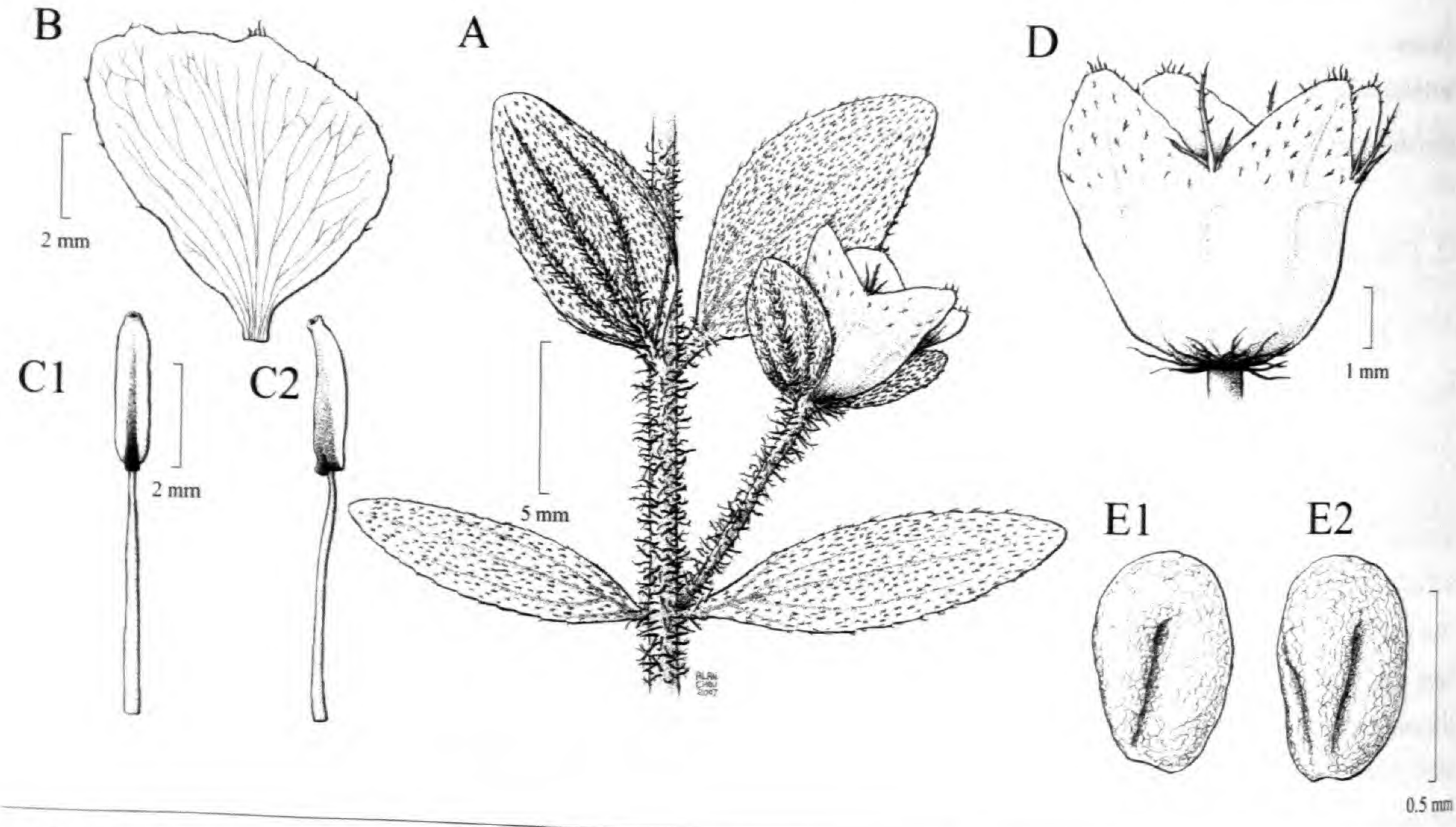


FIG. 23. *Chaetolepis santamartensis*. **A.** Habit. **B.** Petal (adaxial surface). **C1.** Stamen, dorsal view. **C2.** Stamen, profile view. **D.** Hypanthium. **E1.** Seed, profile view. **E2.** Seed, ventral view (A–E2 from *van der Hammen 1156*, COL).

with smooth, eglandular, antrorsely spreading or appressed trichomes 1–1.5 mm long. Older internodes woody, terete and furrowed with age. Principal leaves coriaceous and spreading; adaxial foliar surface glabrous; abaxial foliar surface glabrous on the primary and secondary veins and punctate between them; blades 5–10 × 1.5–4.5 mm, elliptic to oblong-elliptic, acute apically and basally, 3-nerved; margins serrulate and eciliate, sessile. Inflorescence usually a terminal, simple dichasium. Bracts much like principal leaves. Bracteoles 2.5–3.5 × 1–1.5 mm, narrowly elliptic to narrowly obovate, acute apically and basally, glabrous abaxially, punctate between the primary and secondary veins and glabrous on the actual elevated veins; subsessile or with petioles 0.3–0.5 mm long. Floral pedicels 1–2 mm long, beset with sessile glands. Hypanthia (at anthesis) 4.5–8 × 2.5–3.5 mm, urceolate, moderately covered with sessile glands and sparsely to moderately covered with appressed, eglandular trichomes; hypanthia (at maturity) with conspicuously elevated vascular ribs. Calyx lobes 1.5–2.5 × 0.8–1.2 mm, lance-deltoid, apically acute, ascending, sometimes spreading or reflexed, ciliate; calyx lobes moderately covered with sessile glands both on and off the midrib; intercalycine lobe sinus with bifurcate or trifurcate trichomes. Petals 5–6 × 3.5–4.5 mm, yellow, margins entire, glabrous, apically cuspidate with a terminal trichome. Filaments 5–6 mm long, yellow; anthers 3.5–4 mm long, yellow, linear to arcuate; pore ventrally inclined; connective prolonged 0.5–0.8 mm below the thecae. Ovary sparsely covered apically with appressed smooth eglandular trichomes; style 5–7 mm long, yellow. Seeds 0.4–0.6 mm long, brown. Chromosome number: unknown.

Flowering.—March to June.

Habitat and Distribution (Fig. 21).—Known only from Mérida, Venezuela, in Don Pedro and Aricagua páramos at 2800–3300 m.

Discussion.—Only two collections of *Chaetolepis sessilis* were available for study. Despite limited material, this species is readily distinguished by a variety of characters. It has smooth eglandular trichomes on the abaxial leaf surface between the primary and secondary veins, cauline nodes, and hypanthia. It also has sessile glands on the cauline internodes, calyx lobes, and hypanthia, 3-nerved blades that are serrulate and eciliate, a bifurcate or trifurcate trichome at each intercalycine sinus, and a ventrally inclined anther pore (Fig. 24).

The closest relative of *Chaetolepis sessilis* appears to be *C. perijensis* var. *perijensis*. Both species have ses-

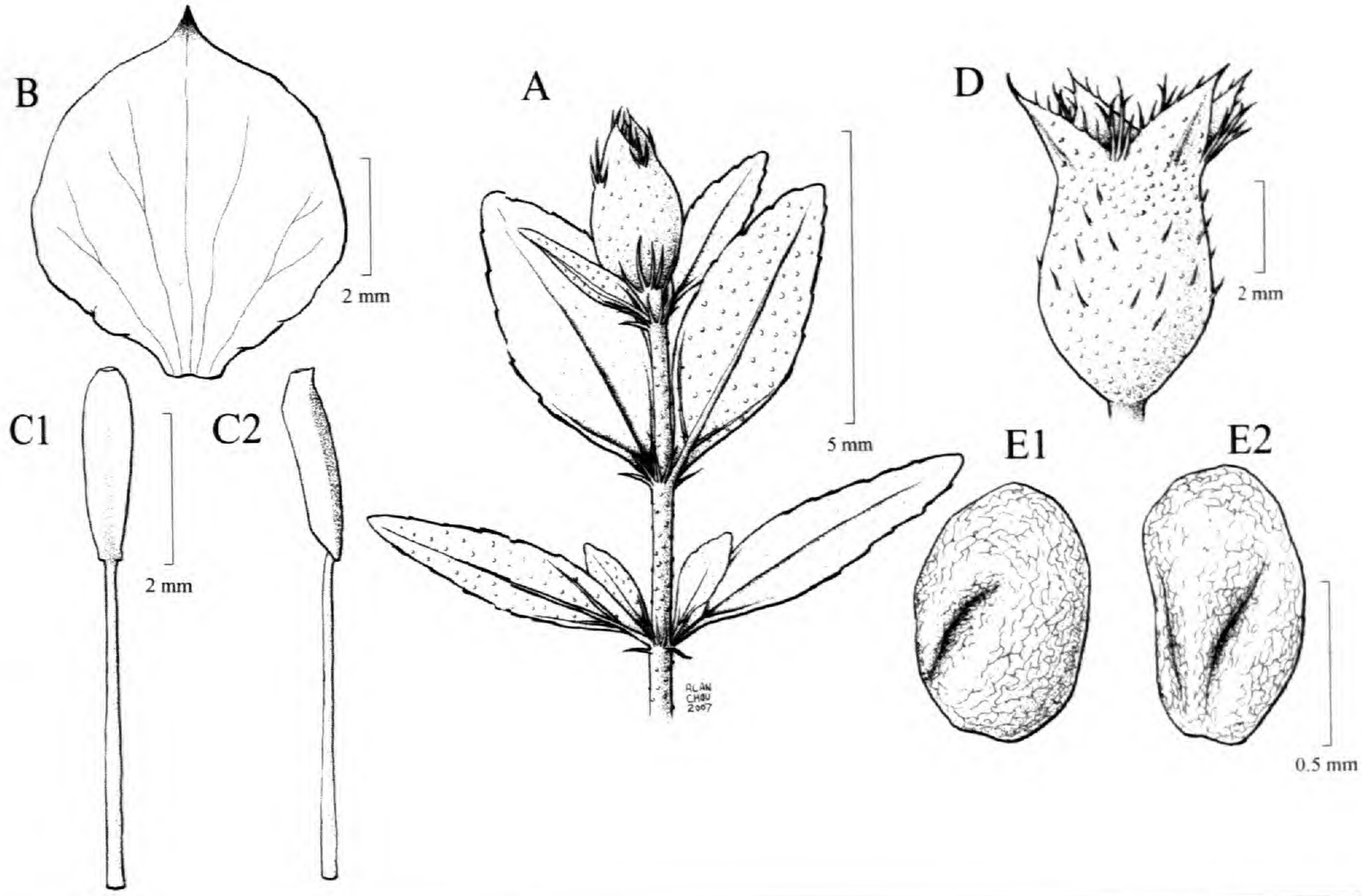


FIG. 24. *Chaetolepis sessilis*. **A.** Habit. **B.** Petal (adaxial surface). **C1.** Stamen, ventral view. **C2.** Stamen, profile view. **D.** Hypanthium. **E1.** Seed, profile view. **E2.** Seed, ventral view (A–E2 from *Ruiz-Terán & López-Figueiras 8658a*, F).

sile glands on the cauline internodes, calyx lobes, and hypanthia. They also share smooth eglandular trichomes on the abaxial leaf surface between the primary and secondary veins and on the cauline nodes.

Chaetolepis perijensis var. *perijensis* is unlike *C. sessilis* in having leaf blades with a single primary vein; its leaf margins are ciliate and entire; the adaxial leaf surfaces and cauline nodes are covered with sessile glands; and the abaxial leaf surface is punctate. Furthermore, the hypanthium is glabrous, the intercalycine sinuses have smooth eglandular trichomes, and the anther pore is dorsally inclined.

Representative specimens examined: **VENEZUELA. Mérida:** Páramo de Don Pedro, unos 20–22 kms al ESE de la población de El Morro, distrito Libertador, *Ruiz-Terán & López-Figueiras 8658a* (F, US).

EXCLUDED SPECIES

Chaetolepis cubensis (A. Rich.) Triana, Trans. Linn. Soc. London 28:51. 1871. BASIONYM: *Arthrostemma cubense* A. Rich., in Sagra, Hist. Fis. Cuba, Bot. 10:550. 1845. TYPE: CUBA: *de la Sagra s.n.* (HOLOTYPE: P!; ISOTYPES: BR!, G!, GH, MO!). *Chaetogastra cubensis* (A. Rich.) Griseb., Cat. Pl. Cub. 103. 1866. = *Tibouchina cubense* (A. Rich.) M. Gómez, Análes Hist. Nat. 23:68. 1894.

Chaetogastra cubensis var. *brevistrigillosa* Griseb., Cat. Pl. Cub. 103. 1866. TYPE: CUBA: Savana del Ciego, *Wright 2529* (HOLOTYPE: GOET, internet image!: ISOTYPES: BR!, G!, GH!, K, internet image!, MO!, P, internet image!). *Chaetolepis saturaeioides* var. *brevistrigillosa* (Griseb.) Triana, Trans. Linn. Soc. London 28:51. 1871. *Chaetolepis brevistrigillosa* (Griseb.) Cogn., in A.DC. & C. DC., Monogr. Phan. 7:172. 1891.

Chaetogastra origanoides Griseb., Cat. Pl. Cub. 103. 1866. TYPE: CUBA: *Wright 2530* (HOLOTYPE: GOET, internet image!; ISOTYPE: K, internet image!).

Chaetogastra saturejoides Griseb. Cat. Pl. Cub. 103. 1866. TYPE: CUBA: *Wright 2531* (HOLOTYPE: GOET, internet image!: ISOTYPES: BR!, G!, MO!, P!). *Chaetolepis saturejoides* (Griseb.) Triana, Trans. Linn. Soc. London 28:51. 1871.

Pleroma squamatum C. Wright, Anal. Acad. Ci. Habana 6:73. 1869. *Tibouchina squamata* (C. Wright) M. Gómez, Anales Hist. Nat. 23:68. 1894. TYPE: CUBA: *Wright 3559* (HOLOTYPE: GH).

Chaetolepis grisebachii Cogn., in A.DC. & C.DC., Monogr. Phan. 7:172. 1891. TYPE: CUBA: *Wright 2528* (HOLOTYPE: GOET; ISOTYPES: MO, internet image!, S, internet image!).

ACKNOWLEDGMENTS

We thank Peter W. Fritsch and Robert W. Patterson for early reviews of the manuscript and for patient help with all the cladistic analyses. Two anonymous reviewers are thanked for critical and constructive reviews. We are also grateful to Alan Chou for the line drawings, Charlotte Pfeiffer for technical assistance with many of the figures, Scott Serata for assistance in the Scanning Electron Microscope Laboratory at CAS, Sabina King for editorial assistance with many iterations of the manuscript, Carlos Parra and Eduino Carbonó for facilitating loans of important specimens from Colombia, and the curators and staffs of the following herbaria for loans or assistance during study visits: BM, BR, CAS, COL, DS, DUKE, F, FMB, G, GH, HECASA, K, M, MO, NY, P, US, and UTMC. We also thank the Andrew W. Mellon Foundation and JSTOR Plant Science for supporting and facilitating the creation of a global online image resource for vascular plant type specimens. The facilities and logistical support of San Francisco State University and the California Academy of Sciences is also gratefully acknowledged.

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BOOK REVIEW

ARTHUR HAINES, WITH ILLUS. BY ELIZABETH FARNSWORTH AND GORDON MORRISON. 2011. **New England Wild Flower Society's FLORA NOVAE ANGLIAE: A Manual for the Identification of Native and Naturalized Higher Vascular Plants of New England.** (ISBN: 978-0-300-17154-9, cloth). Yale University Press, P.O. Box 209040, New Haven, Connecticut 06520-9040, U.S.A. (**Orders:** www.yalebooks.com, 1-203-432-0163, 1-203-432-8485 fax). $85.00, 1008 pp., 945 b/w illus., 7" × 9 ½".

The states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont are usually considered the New England area and they are the focus of this much needed, new and updated study of their flora. In 2001 the New England Wild Flower Society hired Haines to visit every herbarium in the area and check out every rare plant specimen to determine if it still existed in the area, if it had been properly identified, and correctly named. His two-year study of the specimens indicated that one of every twelve specimens required clarification "to correct a misidentification or to identify a new species or infraspecific taxon that had been named since it had been collected." Although a couple of new floras for the area had been published previously, they primarily relied on M.L. Fernald's 1950 edition (the 8th) of *Gray's Manual of Botany*. This new volume is based on the outstanding work of current and recently deceased botanists, and it is a treasure-house of excellent research, field studies, and dedication to botany.

Following a very helpful Introduction and an updated Glossary of Terminology, is the Key to the Families, pp. 1–37. The heart of the book, though, is the whole set of taxonomic treatments (pp. 39–890). These are divided into the subgroups Lycophytes, Monilophytes, Gymnosperms, Magnoliids, Monocots, and Tricolpates.

Pages 891–915 contain the Literature Cited section. This is an amazing citing of the works of some of the most dedicated and talented botanists of the last half century as well as the current one. Just glance through this section. You will undoubtedly recognize name after name of botanists that you know or have known in the recent past—or perhaps, you simply recognize through your reading—and whose research and contributions have made a huge contribution to understanding better the flora of New England.

This volume is an outstanding contribution. The New England Wild Flower Society has provided a great service to all of us.—*Helen Jeude, Volunteer & Assistant Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

MICONIA PHRYNOSOMADERMA (MELASTOMATACEAE: MICONIEAE), A NEW SPECIES FROM THE MASSIF DU NORD, HAITI, AND SIXTEEN NEW NAMES AND COMBINATIONS

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ABSTRACT

During revisionary studies of the Greater Antillean *Lima* clade of *Miconia*, we discovered a previously undescribed species, **Miconia phrynosomaderma.** We herein describe this new species, compare it with putative close relatives, and provide an illustration and distribution map. *Miconia phrynosomaderma* is endemic to northern Haiti and known only from the type collection. This species represents yet another new species described from the priceless collections made in the Greater Antilles by the Swedish botanist, Erik L. Ekman. A new section of the genus *Miconia* is described, **Miconia** sect. **Lima,** which is recognized based on a suite of putative morphological synapomorphies. We also make 16 new combinations or new names for members of the *Lima* clade and closely related species that previously were recognized under *Leandra* and/or *Ossaea*.

RESUMEN

Durante estudios taxonómicos del clado *Lima* de *Miconia* de las Antillas Mayores, descubrimos una nueva especie para la ciencia, **Miconia phrynosomaderma.** En este manuscrito describimos esta nueva especie, la comparamos con sus parientes putativos, y aportamos una ilustración y un mapa de distribución. *Miconia phrynosomaderma* es endémica de Haití y conocida solo por la colección tipo. Esta especie representa otra nueva especie más descrita de las colecciones imprescindibles de las Antillas Mayores del botánico sueco, Erik L. Ekman. Se describe una nueva sección de *Miconia*, **Miconia** sect. **Lima,** la cuál se reconoce por caracteres morfológicos. También hacemos 16 nuevas combinaciones o nuevos nombres para miembros del clado *Lima* y parientes, que antes se reconocían bajo los géneros *Leandra* y/u *Ossaea*.

INTRODUCTION

The famous Swedish botanist, Erik L. Ekman, was a voracious collector and incredible taxonomist. He has been described by some as a wild animal in the way he collected plants, as he made easy work of terrain quite difficult for most botanists. He was known for his broad knowledge of the flora of Cuba and Hispaniola, his thoroughness, beautiful collections, and also his indifference to adverse climatic conditions while in the field (Standley 1931; Wolcott 1931). As an avid collector and well-trained botanist, he discovered hundreds of new species in Cuba and Hispaniola, many of which were described either by German botanist, Ignaz Urban, Ekman himself, or Urban and Ekman together (Urban 1923, 1927, 1929, 1931; Standley 1931). However, of the numerous collections made by Ekman, many are still yielding species new to science (e.g., Judd & Beaman 1988; Judd et al. 1988; Judd 1994; Guerrero et al. 2004; Judd & Majure 2013). Likewise, the new species presented in this paper is the result of a collection of a rare *Miconia* Ruiz & Pav. from northern Haiti made by Ekman in 1927.

As currently circumscribed, the genus *Miconia* of tribe Miconieae, is extremely polyphyletic, having numerous other genera, e.g., *Calycogonium* DC., *Clidemia* D. Don, *Conostegia* D. Don, *Leandra* Raddi, *Mecranium* Hook., *Ossaea* DC., *Pachyanthus* A.Rich., *Tetrazygia* Rich., nested within it. However, most of those genera also are non-monophyletic, as several recent molecular phylogenetic analyses (Bécquer et al. 2008; Goldenberg et al. 2008; Michelangeli et al. 2004, 2008) as well as unpublished data (Michelangeli, in prep.) have shown. The problematic generic circumscriptions within Miconieae have been discussed by numerous authors (Cogniaux 1891; Gleason 1932; Macbride 1941; Wurdack 1972; Judd 1986, 1989, 2007; Judd & Skean 1991; Martin et al. 2008; Martin & Michelangeli 2009; Ionta et al. 2012). Cogniaux (1891) even considered the delimitation of

genera in the group to be arbitrary. It is quite clear that generic circumscription within this group is in need of revision, however, the splitting of *Miconia* would lead to a proliferation of new genera, many of which would be morphologically undiagnosable and of problematic circumscription (see Ionta et al. 2012). In contrast, the Miconieae can be diagnosed by several morphological synapomorphies: partly or entirely inferior ovaries, baccate fruits, stamens without or merely with poorly developed connective appendages, and the absence of megastyloids (Michelangeli et al. 2008). Therefore, it is more useful to recognize a broadly circumscribed *Miconia*, including all those species of Miconieae with berry fruits, while recognizing well-supported, less inclusive clades with clear morphological synapomorphies as subgenera or sections of *Miconia* (Ionta et al. 2012; Ionta & Judd 2012).

The Greater Antillean *Lima* clade within *Miconia* is a good example of the problem of arbitrarily circumscribed traditional genera within Miconieae, as it contains species that have been recognized as *Calycogonium*, *Clidemia*, *Leandra*, *Miconia*, *Ossaea*, *Oxymeris* DC., and *Sagraea* DC., although most species within this monophyletic group are currently recognized within either *Leandra* or *Ossaea* (Alain 1957; Judd & Skean 1991; Liogier 2000; Michelangeli & Bécquer 2012). *Leandra* and *Ossaea* were traditionally recognized based on their acute petal apices, a feature exhibited by most members of the *Lima* clade. *Leandra* is widely polyphyletic, although, *Leandra* s.str. (including the type *L. melastomoides* Raddi; Martin et al. 2008) is a clade quite distantly related to the *Lima* clade. The nomenclatural status of *Ossaea* is problematic, as no type has been designated. However, of the species, which could be used as the type of the genus, none of those are closely related to the *Lima* clade. So even if most of the species of Miconieae were not included in *Miconia* s.l., neither *Leandra* nor *Ossaea* would be the correct genera for members of the *Lima* clade. Thus, we herein describe this clade as a new section within *Miconia*, i.e., *Miconia* sect. *Lima*. For the above stated reasons, we justify the description of the new species within *Miconia* s.l.

Members of *Miconia* sect. *Lima* represent a clade that is restricted to the Greater Antilles and consists of 17 known species, including *Miconia phrynosomaderma*, which is described herein. The monophyly of sect. *Lima* is well supported in molecular phylogenetic analyses (Goldenberg et al. 2008; Martin et al. 2008; Michelangeli et al. 2008; Michelangeli et al., in prep.) and by morphological characters. Putative synapomorphies of this clade are numerous, including the striking and well-developed bulla-based hairs on the adaxial leaf surface (Fig. 1), as well as the ephemeral, long-stemmed, clavate-dendritic hairs on the adaxial leaf surface of developing leaves (which are produced from in between the large bulla-based hairs towards the leaf base along primary, secondary, and occasionally tertiary veins). These clavate-dendritic hairs are also produced at the inflorescence nodes, emerging between the bulla-based hairs. Bulla-based hairs are also produced on other plant parts, e.g., the abaxial leaf surface, stems, inflorescence axes, hypanthia, calyx teeth, and the upper surface of the ovary, although these have narrower bases in most species, as compared to those of the adaxial leaf surface. Sessile glands, another likely apomorphy, are present on the adaxial and abaxial leaf surfaces, hypanthium, and calyx lobes. The flowers produce petals with acute to acuminate apices that bear large bulla-based hairs from the medial portion and/or apex of the petal, and the presence of these distinctive hairs likely is also synapomorphic (Fig. 1). Finally, the anthers generally have a dorso-basal appendage and one dorsally oriented pore, both likely apomorphies.

Inflorescences are terminal and fruits have terete calyx teeth (Fig. 1), and although distinctive, both are likely retained plesiomorphies. The ovaries are typically slightly four- or five-lobed, although this if often obscured by the dense bulla-based hairs.

TAXONOMIC TREATMENT

Miconia sect. **Lima** Majure & Judd, sect. nov. TYPE: *Miconia lima* (Desr.) M. Gómez, Anales Hist. Nat. 23:69. 1894. BASIONYM: *Melastoma lima* Desr. in Lam. Encyc. 4:47. 1797. *Clidemia lima* DC., Prodr. [A.P. de Candolle] 3:161. 1828. *Sagraea lima* (Desr.) Naud., Ann. Sci. Nat., Bot. sér. 3, 18:99. 1852. *Calycogonium lima* (Desr.) Griseb., Cat. Pl. Cub. [Grisebach] 95. 1866. *Ossaea lima* (Desr.) Triana, Trans. Linn. Soc. London 28:147. 1871–1872. *Leandra lima* (Desr.) Judd & Skean, Bull. Florida Mus., Biol. Sci. 36:61. 1991.

Ossaea lima (Desr.) Triana var. *grandifolia* Cogn., Monogr. Phan. 7:1061. 1891.

Ossaea lima (Desr.) Triana var. *ovalifolia* Cogn., Symb. Antill. 7:531. 1913.

Trichomata basibus bulliformis per corpus plantae; trichomata longa et clavatidendritica in pagina adaxiali foliorum juvenium; trichomata glandulosa, sessilia a subsessilia, in pagina adaxiali foliorum, inter trichomata bulliformia; trichomata glandulosa, sessilia, in pagina abaxiali foliorum, hypanthio et lobis calycis; petala acuta (vel acuminata) cum trichomatibus basibus bulliformis in pagina abaxiali.

Evergreen shrubs; young **stems** terete, elliptic or slightly rectangular in cross section, lacking longitudinal ridges, the indumentum of dense bulla-based hairs, these long appressed, spreading, or recurved, or short and granulate. **Leaves** opposite, slightly anisophyllous; blade elliptical, ovate, or narrowly ovate, the margin crenulate to dentate, these crenulations/dentations obscured by large bulla-based hairs, which slightly fold over the leaf margin, producing in some cases a moderately revolute margin, the indumentum of adaxial leaf surface typically of broad bulla-based hairs ± filling areoles, although sometimes these hairs relatively narrow and wide-spaced, not filling the areoles, with long-stemmed, clavate-dentritic hairs produced along the primary, secondary and tertiary veins from between the bulla-based hairs, and also sessile to short-stalked glandular hairs present on all parts of the lamina (between bulla-based hairs), the abaxial leaf surface variously covered by narrow bulla-based hairs, these either long and well developed or short and granulate, these appressed, spreading, or erect, the lamina with sparse, sessile glands, the venation acrodromous, with secondary veins arching toward leaf apex, 1 to 3 pairs, basal to suprabasal, tertiary veins percurrent, ± perpendicular to the midvein, sometimes mostly obscured by bulla-based hairs on the adaxial leaf surface, connected by quaternary veins, the primary, secondary, tertiary and quaternary veins mostly impressed on the adaxial surface and raised on the abaxial surface, domatia present or absent, occurring at the junctions of primary, secondary and tertiary veins, forming a pocket-like structure in the axils of the primary and innermost secondary veins or formed from a tuft of hairs in the vein axils. **Inflorescences** terminal, although often surpassed by the rapid growth of axillary shoots, the flowers in 3-flowered dichasia, sessile, subsessile or pedicellate, thus forming open cymes or sessile and nearly headlike clusters. **Flowers** 4–5(6) merous, mostly actinomorphic or nearly so; hypanthium 4–5 lobed, the lobes sometimes obscured by retrorse or antrorse bulla-based hairs, bulla-based hairs long and well developed, or granulate, hypanthium also with sessile glands; calyx lobes triangular, acute to acuminate, often covered by sessile glands throughout the adaxial surface or such glands restricted to the apex of the adaxial surface, abaxial surface covered in bulla-based hairs and ± sessile glands; calyx teeth ± equal or longer than calyx lobes, terete, mostly reflexed in fruit, covered in long and well developed, or granulate bulla-based hairs, sessile glands present or absent; calyx tube often with long stemmed, clavate-dendritic hairs produced from apex along the margin, sessile glands ± present on adaxial surface, abaxial surface covered in bulla-based hairs; petals ovate to obovate or slightly oblong, symmetric or asymmetric, white, red, rose, purple, or white with purple tinge abaxially, apices acute to acuminate, with moderately bulla-based hairs produced from the abaxial surfaces just below the petal apex and occasionally from the medial portion of the petal as well; stamens 8–10(–12), not geniculate, the filaments glabrous, the anthers with or without a small dorso-basal appendage and a single, dorsally inclined pore; style straight to moderately curved, generally expanded in the middle, the stigma punctiform; ovary 2–5 locular, ± inferior, with axile placentation, the placenta intruded into each locule, the ovary apex without a collar but commonly with a crown of multicellular hairs, the upper portion of the ovary pubescent (bulla-based hairs) to mostly glabrous (i.e., with only crown hairs present). **Berries** globose and slightly 4- or 5-lobed, purple-black at maturity. **Seeds** angular, obpyramidal, obovoid to obovoid-falcate, with a linear to oblong, dark colored raphe that extends the length of the seed; testa smooth; appendage absent.

Etymology.—The name *Lima* is derived from the Latin, *lima*, which refers to a file. The bulla-based hairs on the adaxial leaf surface of *Miconia lima* and other members of the clade form a pattern very similar in appearance to that of a file or rasp. Hence, we found it appropriate to use the name *Lima* for this section of *Miconia*.

The following new combinations or new names for species of *Miconia* sect. *Lima* are required. Three other species, *Miconia inaequipetiolata*, *M. karlkrugii* and *M. krugiana*, also are included. Although they are not part of the *Lima* clade (Michelangeli et al., unpubl. data, Majure et al. in prep.), morphological and phylogenetic data suggest that they are closely related.

Miconia argentimuricata Majure & Judd, nom. nov. *Calycogonium muricatum* Griseb., Cat. Pl. Cub. 95. 1866. *Ossaea muricata* (Griseb.) C. Wright, Anal. Acad. Ci. Habana 5:434. 1868. TYPE: CUBA: Cuchillos de Baracoa, 14 May 1860–1864, *C. Wright 2485* (LECTOTYPE designated by Howard 1984: GOET! online image seen GOET007038!; ISOLECTOTYPES: GH! MO!). Non *Miconia muricata* (D. Don) Triana, Trans. Linn. Soc. London 28:102. 1871.

The new epithet is meant to call to mind the original epithet and also reflect the silver coloration of the adaxial surface of dried leaves of this species.

Miconia asperifolia (Naudin) Majure & Judd, comb. nov. *Clidemia asperifolia* Naudin, Ann. Sci. Nat., Bot. sér. 3, 17:342. 1852. *Oxymeris asperifolia* (Naudin) Triana, Trans. Linn. Soc. London 28:96. 1871–72. *Ossaea asperifolia* (Naudin) Triana, Trans. Linn. Soc. London 28:147. 1871–72. TYPE: JAMAICA: In insula Jamaica, loco haud indicato. Planta a celeberrimo Hooker communicate (n.v.).

Note that *Clidemia hirsuta* Macfad., Fl. Jamaica 2:45. 1850., also represents this species, but it is not considered here to be effectively published, and thus is not validly published. The name *Clidemia hirsuta* (Sw.) Griseb. (Fl. Brit. W. I. 248. 1860.) represents a different species.

Miconia cubacinerea Majure & Judd, nom. nov. *Clidemia cinerea* Griseb., Cat. Pl. Cub. 97. 1866. *Oxymeris cinerea* (Griseb.) Triana, Trans. Linn. Soc. London 28:92. 1871. *Leandra cinerea* (Griseb.) Cogn., Fl. Bras. (Martius) 14:71. 1886. *Maieta cinerea* (Griseb.) M. Gómez, Anales Hist. Nat. 23:71. 1894. Non *Miconia cinerea* Cogn., Fl. Bras. (Martius) 14(4):290. 1887. TYPE: CUBA: Yunque de Baracoa, 11 Jun 1860–1864, *C. Wright 2483* (HOLOTYPE: GOET! online image seen GOET007034; ISOTYPES: BM! online image seen BM000884493, BR! online image seen BR0000005185191, GH!, K! online image seen K000535607, MO! YU! online image seen YU065014).

The specific epithet, *cubacinerea*, refers to the restricted distribution of this species, which is only known from Cuba.

Miconia cubana (Alain) Majure & Judd, comb. nov. *Ossaea cubana* Alain, Contr. Ocas. Mus. Hist. Nat. Col. "de la Salle" 14:11. 1955. TYPE: CUBA: Isabel María, 16 Mar 1860–1864, *C. Wright 189* (HOLOTYPE: NY!; ISOTYPES: GH!, HAC! image seen, HAJB! image seen, S!).

Miconia granulata (Urb.) Majure & Judd, comb. nov. *Ossaea granulata* Urb., Symb. Ant. 9:125. 1923. TYPE: CUBA. ORIENTE: Baracoa at Minas de Yberia (pr. Taco Bay) in "charrascales," 7–8 Dec 1914, *E.L. Ekman 3789* (HOLOTYPE: S!; ISOTYPE: NY!).

Miconia hybophylla (Urb.) Majure & Judd, comb. nov. *Ossaea hybophylla* Urb., Ark. Bot. 21A:51. 1927. *Leandra hybophylla* (Urb.) Alain, Sida 18:1026. 1999. TYPE: HAITI: Massif des Cahos, Petite-Riviére de l'Artibonite, Pérodin, at Ingram, 7 Mar 1925, *E.L. Ekman H3440* (HOLOTYPE: S!; ISOTYPES: K! online image seen K000535605, NY!, US!).

Miconia inaequipetiolata Majure & Judd, nom. nov. *Ossaea inaequidens* Urb. & Ekm., Ark. Bot. 22A, 17:63. 1929. *Leandra inaequidens* (Urb. & Ekm.) Judd & Skean, Bull. Florida Mus., Biol. Sci. 36:61. 1991. TYPE: HAITI. Massif de la Selle, Croix-des-Bouquets, Badeau, at Trou-á-l'Sau, 1000m, 15 Mar 1927, *E.L. Ekman H7860* (HOLOTYPE: S!; ISOTYPES: K! online image seen 000329545, NY!). Non *Miconia inaequidens* (DC.) Naudin, Ann. Sci. Nat., Bot., Ser. 3 16:245. 1850.

Urban and Ekman (1929) referred to the unequal petioles of this species in the protologue, and thus we highlight this characteristic in the new epithet.

Miconia jashaferi Majure & Judd, nom. nov. *Ossaea shaferi* Britton & Wilson, Mem. Torrey Club 16:92. 1920. TYPE: CUBA. ORIENTE: Camp La Gloria, S of Sierra Moa, *J.A. Shafer 8152* (HOLOTYPE: NY!; ISOTYPE: A!, CAS!, online image seen CAS0003716). Non *Miconia shaferi* Cogn. in Urb., Symb. Antill. 7:312. 1912.

The new epithet, like the original one, honors John Adolph Shafer (1863–1918).

Miconia karlkrugii Majure & Judd, nom. nov. *Calycogonium krugii* Cogn., Bot. Jahrb. Syst. 4:279. 1886. *Leandra krugii* (Cogn.) Judd & Skean, Bull. Florida State Mus., Biol. Sci. 36:61. 1991. *Ossaea krugii* (Cogn.) F.S. Axelrod, Sida, Bot. Misc 34:214. 2011. TYPE: PUERTO RICO: Maricao in declivibus montis "Alegrillo," 26 Nov 1884, *P. Sintensis 293* (HOLOTYPE: BR! online image seen BR0000005193479; ISOTYPES: CORD! online image seen CORD00003589, GH!, GOET! online image seen GOET007892, K! online image seen, MO!, MPU! online image seen MPU013629, NY!, S!, US!). Non *Miconia krugii* Cogn., in A.DC. & C.DC., Monogr. Phan. 7:932. 1891.

The specific epithet *karlkrugii* honors the botanist Karl Wilhelm Leopold Krug (1833–1898) for which the species was first named.

Miconia krugiana (Cogn.) Majure & Judd, comb. nov. *Ossaea krugiana* Cogn., Monog. Phan. 7:1048. 1891. *Leandra krugiana* (Cogn.) Judd & Skean, Bull. Florida State Mus., Biol. Sci. 36:61. 1991. TYPE: PUERTO RICO: Adjuntas, in sylva juxta flumen ad Junco, 24 Jun 1886, *P. Sintensis 4642* (HOLOTYPE BR! online image 519349; ISOTYPES: A!, CAS! online image seen CAS0003714, CORD! online image seen CORD00003622, F!, GOET! online image seen GOET008048, GH!, K! online image seen, M! online image seen M0165768, MO!, NY!, US!).

Miconia limoides (Urb.) Majure & Judd, comb. nov. *Ossaea limoides* Urb., Ark. Bot. 21A:50. 1927. *Leandra limoides* (Urb.) Judd & Skean, Bull. Florida State Mus., Biol. Sci. 36:61. 1991. TYPE: HAITI: Massif de la Selle, Port au Prince, Morne Malanga, ridge of mountain, Laubwald, eruptives, 1300 m, 28 Jan 1926, *E.L. Ekman H5462* (HOLOTYPE: S!; ISOTYPE: K! online image seen K000329547).

Miconia marigotiana (Urb. & Ekm.) Majure & Judd, comb. nov. *Ossaea marigotiana* Urb. & Ekman, Ark. Bot. 22A, 17:65. 1929. *Leandra marigotiana* (Urb. & Ekman) Alain, Sida 18:1026. 1999. TYPE: HAITI. SUD EST.: Massif de la Selle, Marigot, Sd. Bassin Chotard, 9 June 1928, *E.L. Ekman H10071* (HOLOTYPE: S!; ISOTYPES: GH! NY! US!).

Miconia norlindii (Urb.) Majure & Judd, comb. nov. *Ossaea norlindii* Urb., Symb. Ant. 9:124. 1923. TYPE: CUBA. ORIENTE: Sierra Maestra, La Gran Piedra, supra Daiquiri, 29 Oct 1916, *E.L. Ekman 8136* (LECTOTYPE designated here, as Urban (1923) did not select a type from the two specimens given in the protologue, S!; ISOLECTOTYPE: US!).

Ossaea turquinensis Urb., Symb. Ant. 9:122. 1923. TYPE: CUBA. ORIENTE: Sierra Maestra, in silva jugo septentr. mont. Pico Turquino, 8 Apr 1915, *E.L. Ekman 5303* (HOLOTYPE: S!). Non *Miconia turquinensis* Urb. & Ekman, Repert. Spec. Nov. Regni Veg. 22:228. 1926.

Although *M. norlindii* is currently recognized as *O. turquinensis*, the specific epithet *turquinensis* is already occupied in *Miconia* (Judd 2007). Therefore, the synonym *O. norlindii* is transferred to *Miconia*.

Miconia ottoschmidtii (Urb.) Majure & Judd, comb. nov. *Ossaea ottoschmidtii* Urb., Repert. Spec. Nov. Regni Veg. 24:6. 1927. TYPE: CUBA. GUANTÁNAMO. La Prenda, Apr 1889, *H.F.A. von Eggers 5332* (HOLOTYPE: M! online image # 0165772).

Miconia pedunculata Majure & Judd, nom. nov. *Ossaea polychaeta* Urb. & Ekman, Ark. Bot. 23A:27. 1931. *Ossaea urbaniana* Alain, Brittonia 20:158. 1968. *Leandra polychaeta* (Urb. & Ekm.) Alain, Sida 18:1026. 1999. TYPE: DOMINCAN REPUBLIC: Cordillera Central, Domingo, Loma la Campana, 2 Nov 1929, *E.L. Ekman H11522* (HOLOTYPE: S!; ISOTYPES: K! online image seen K000535603, NY!).

The name *Ossaea urbaniana* was proposed to differentiate *Ossaea polychaeta* from *O. polychaete* Urb. & Ekman, Ark. Bot. 22A:60. 1929. *Leandra urbaniana* (Alain) Alain, Sida 20:1645. 2003, nom. illeg., is a later homonym of *L. urbaniana* Cogn., in Mart., Fl. Bras. 14:148. 1886. A new name is needed for *O. polychaeta*, as both *Miconia urbaniana* Cogn. (Bot. Jahrb. Syst. 42:139. 1908) and *M. polychaeta* Wurdack (Phytologia 23:493. 1972) already exist in this genus. The new epithet refers to the condensed and distinctly pedunculate inflorescence of this species.

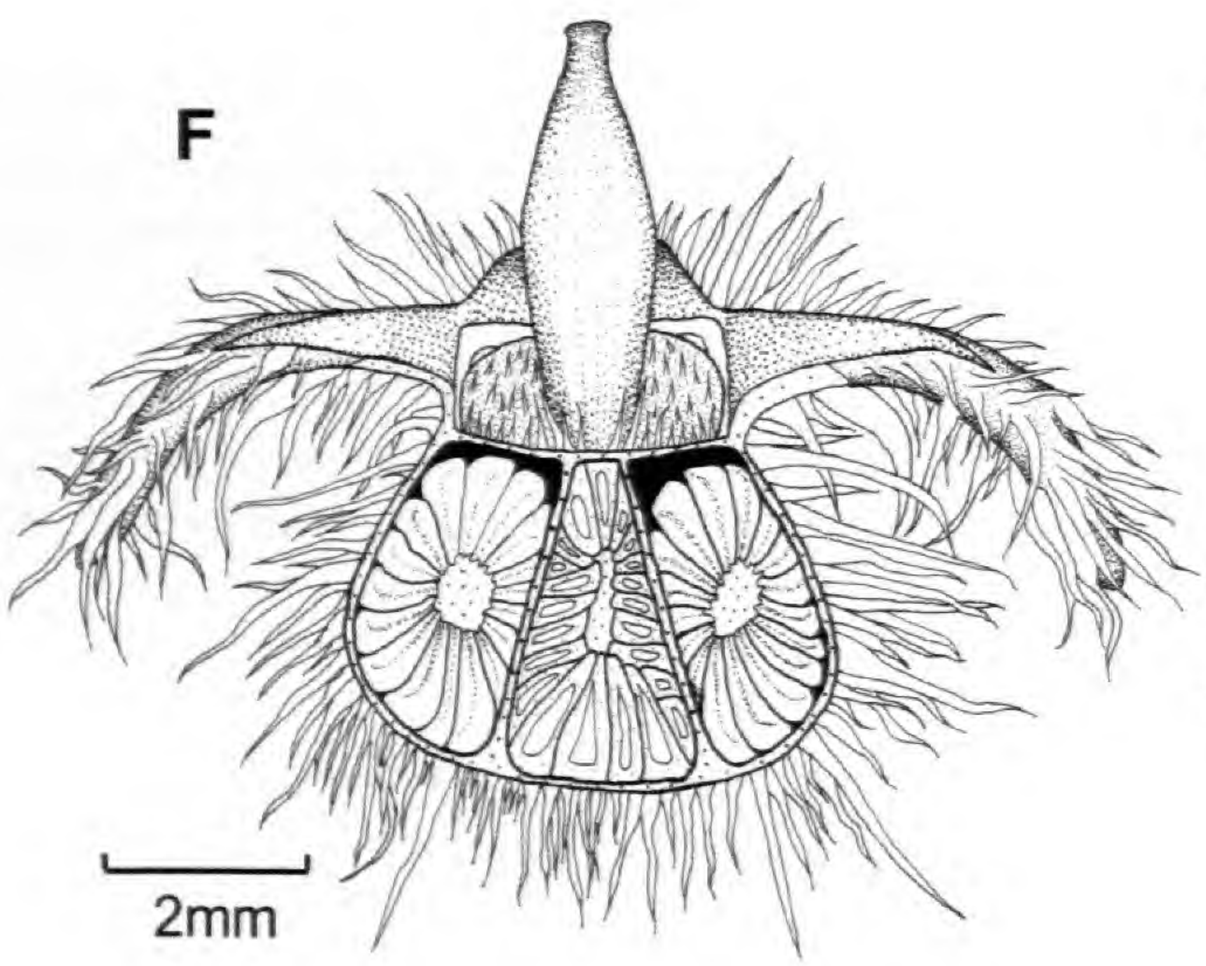
Miconia tentaculicapitata Majure & Judd, nom. nov. *Ossaea capitata* Urb., Rep. Nov. Sp. Fedde 22:237. 1926. TYPE: CUBA: Arroyo del Cristo (tributary of Yara), Sierra Maestra, S of Nagua, 7 Aug 1922, *E.L. Ekman 14748* (HOLOTYPE: S!; ISOTYPES: NY!). Non *Miconia capitata* Ule Notizbl. Königl. Bot. Gart. Berlin 6:360. 1915.

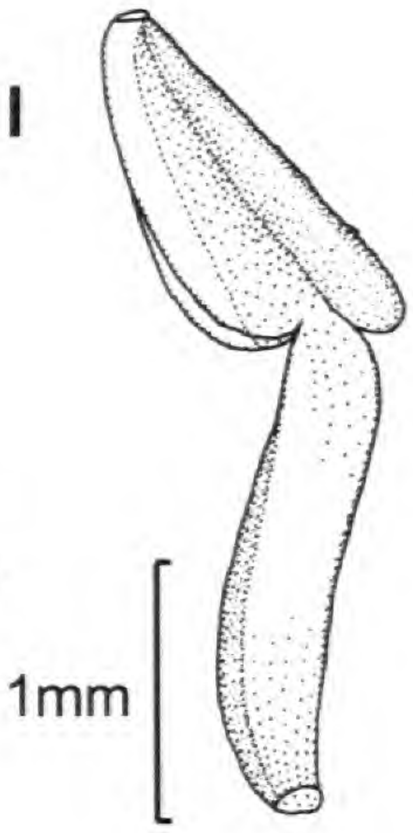
The long calyx teeth of this species resemble tentacles, and this resemblance is reflected in the new epithet, which also serves to mnemonically link the new epithet to the original.

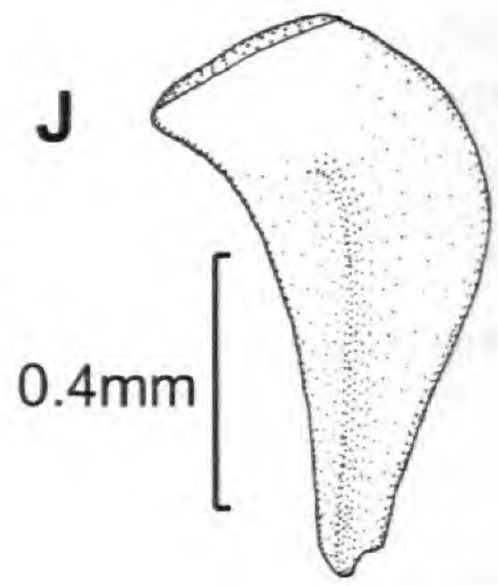
Miconia phrynosomaderma Majure & Judd, sp. nov. (**Fig. 1**). TYPE: HAITI. DEPT. DU NORD: Massif du Nord, Marmelade, Morne Belle-Terre, 1050m, fl, fr, 22 May 1927, *E.L. Ekman H8204* (HOLOTYPE: S!; ISOTYPES: GH! US!).

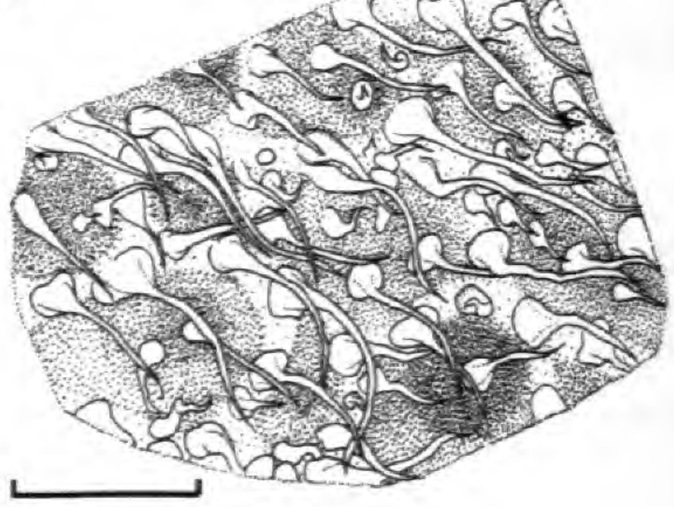
Species haec ab *Miconia limoides* differt indumento caulium apresso-retrorso (non effuse-retrorso); foliis juvenibus purpureo-violaceis (non viridibus); indumento foliorum sparso in paginis adaxiali et abaxiali (non indumento foliorum denso); inflorescentia aperta, floribus pedicillatis (non floribus ± sessilibus); hypanthio sine trichomatibus ad apicem (non trichomatibus annuliformibus ad apicem); dentibus calycis 2.2–3.3 mm longis (non 1.5–2.1 mm longis); petalis albis in pagina adaxiali et purpureis in pagina abaxiali (non roseis, roseolis, vel omnino albis); staminibus dorso-basaliter prolongatis.

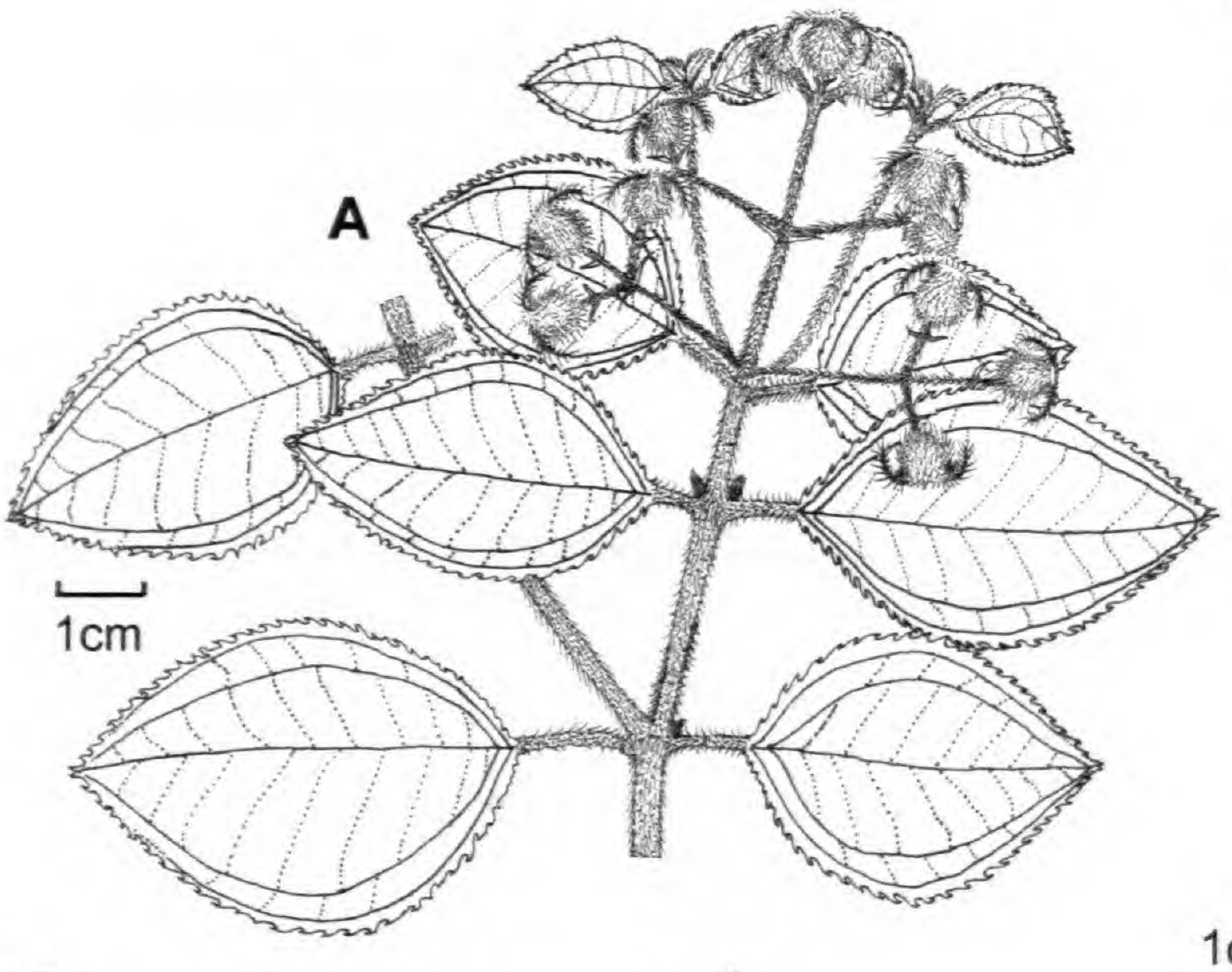
Evergreen shrub (height unknown); **stems** round in cross section, not ridged, the internodes 1–3.2 cm long; stem indumentum of bulla-based hairs 0.4–1.2 mm long, these mixed with some hairs having strongly dilated bases and others only narrowly dilated at the base, the hairs apressed-retrorse along stem or slightly spreading with apices recurved; nodal line present, made up of triangular, bulla-based hairs to 2 mm long. **Leaves** broadly elliptic, 2.4–4.3 × 2–3 cm, often slightly anisophyllous, purplish when young; base rounded to acute; apex broadly acute; venation acrodromous, 5-veined, i.e., with midvein and 2 pairs of arching secondary veins, the innermost pair of secondary veins, mostly symmetrical to subsymmetrical at union with midvein 1.5–5

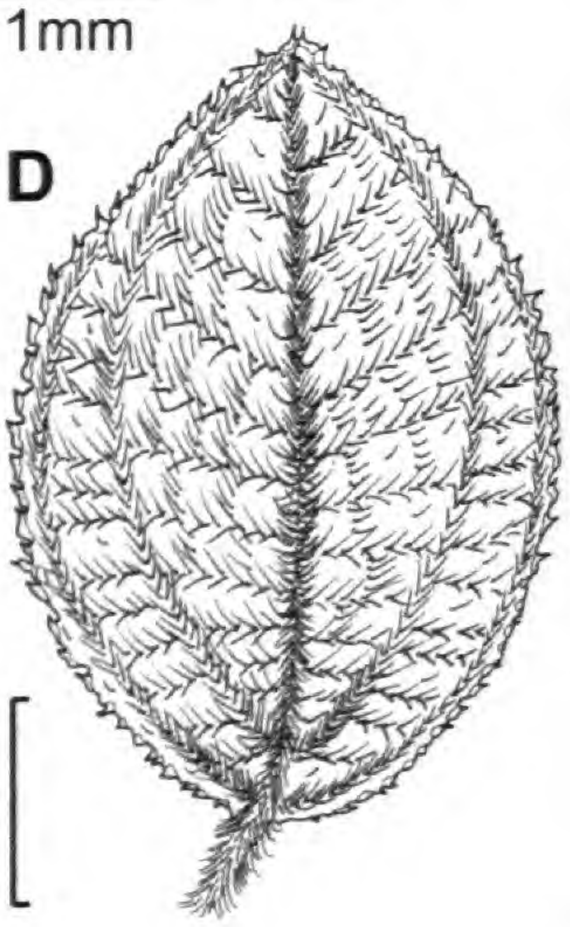


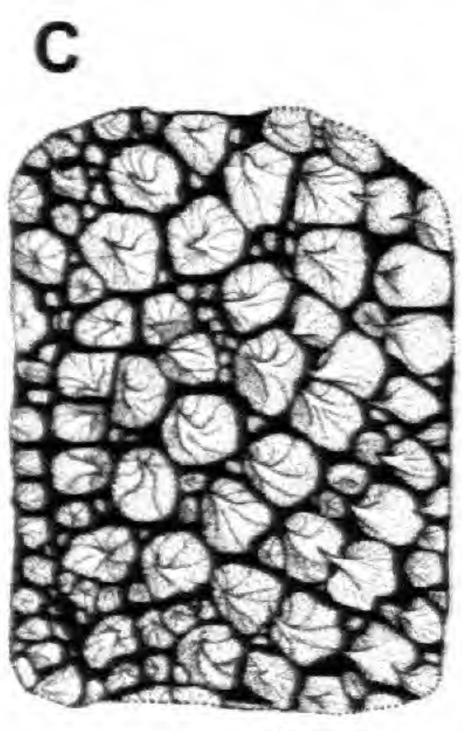


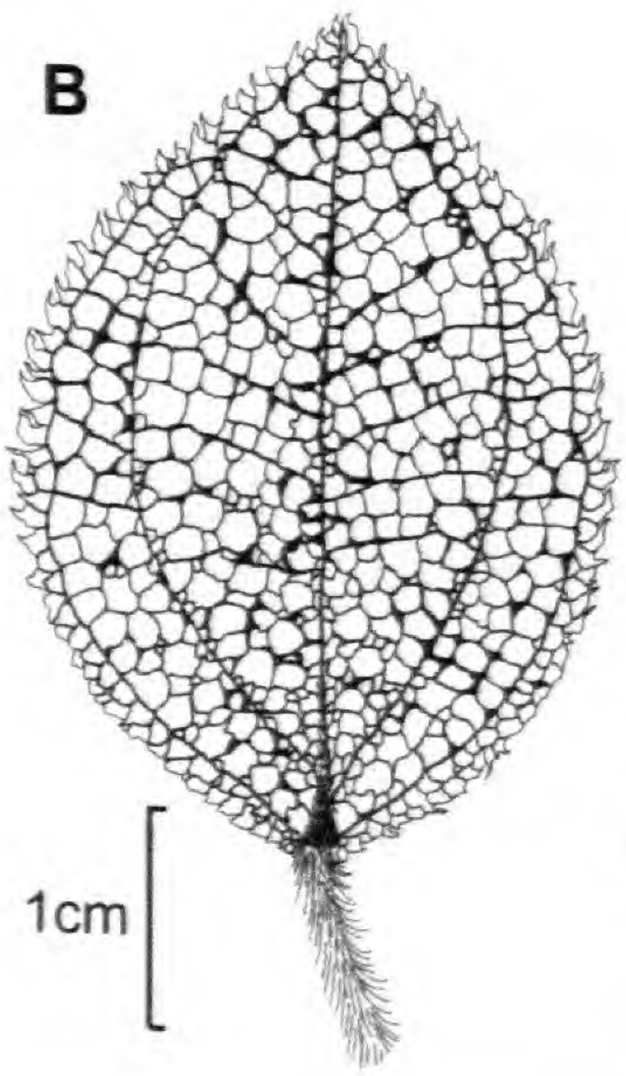












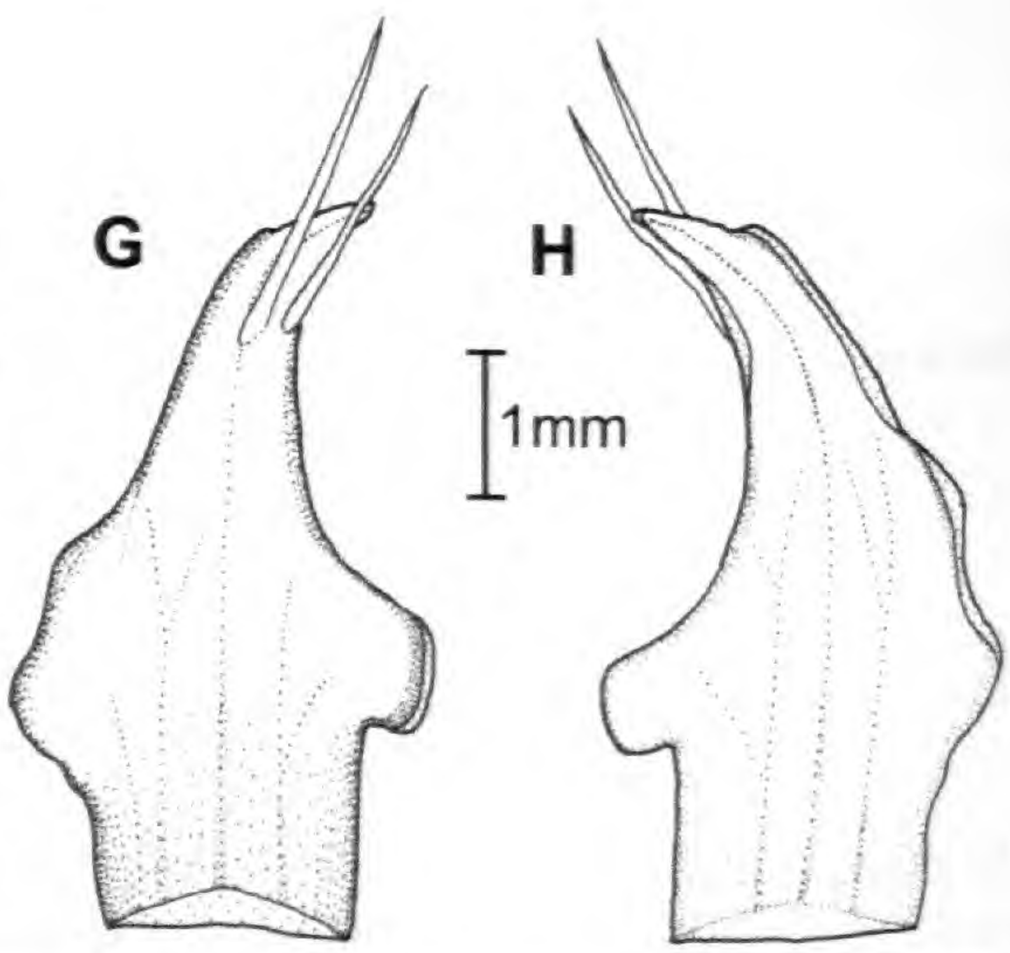


FIG. 1. Illustration of *Miconia phrynosomaderma*. **A)** habit of *M. phrynosomaderma* with the bulla-based hairs removed from the adaxial leaf surface to show venation, **B)** leaf adaxial surface, **C)** close-up of adaxial leaf surface showing expanded bulla-based hairs not fully covering the entire lamina, **D)** leaf abaxial surface, **E)** close-up of abaxial leaf surface showing sparse bulla-based hairs and clearly visible lamina, **F)** longitudinal section (slightly oblique) of young fruit, **G)** petal abaxial surface, **H)** petal adaxial surface, **I)** stamen showing anther with short dorso-basal appendage, **J)** immature seed (all drawn from *Ekman H8204*).

mm above the leaf base, positioned 2.5–5.5 mm in from margin at widest point of blade, the tertiary veins ± perpendicular to midvein, 2.4–3.5 mm apart at mid-leaf; adaxial surface covered in bulla-based hairs, these not meeting at the base, thus the lamina visible between the hairs, i.e., lamina areoles are not completely filled, widest hair bases to 1.8 mm wide, apices of bulla-based hairs mostly erect to slightly spreading, the young leaf adaxial surface with ephemeral, long-stemmed, clavate-dentritic hairs, these sometimes flattened at the apex, arising from between the bases of bulla-based hairs along the primary and secondary veins toward the base of the leaf, and with subsessile to short stalked glandular hairs along the lamina between bulla-based hairs; abaxial leaf surface covered with bulla-based hairs, although the lamina clearly visible, also with bulla-based hairs covering the primary, secondary, tertiary, and quaternary veins, the lamina covered in sessile glands, also with depressions formed from the bulla-based hairs on the adaxial leaf surface; petiole 0.4–1.2 cm long, covered in bulla-based hairs, these spreading to retrorse and recurved on adaxial surface and mostly appressed-retrorse on abaxial surface. **Inflorescences** terminal, well-developed to reduced cymes of 3–15 flowers, 1.7–3.9 cm long, 2.2–5.1 cm across, the peduncle 0.1–0.7 cm long, the proximal branches 0.7–1.7 cm long, the pseudopedicels 1.5–3.5 mm long, and pedicels 0.6–1 cm long; bracts narrowly ovate, 2–3 mm long; bracteoles narrowly ovate, persistent, 2–2.2 mm long, ca. 0.2 mm wide; nodes of inflorescence with mixed bulla-based hairs and long-stemmed, dentritic-clavate hairs, similar to those found at the base of young leaves. **Flowers** 4-merous; hypanthium 3.1–4 mm long, 5–5.2 mm wide, ± spherical, slightly 4-lobed, although lobing mostly obscured by bulla-based hairs 0.9–2.5 mm long, the free portion of hypanthium 0.3 mm long, slightly constricted below the torus, both hypanthium abaxial surface and base of bulla-based hairs with dark, sessile glands; calyx teeth (3.5–4.4 × 0.4–0.7 mm, linear and terete, recurved upon maturation, covered in long, bulla-based hairs; calyx lobes adaxially dark colored (purple?), 1.3 × 1.6 mm, with sessile glands near the apex adaxially and bulla-based hairs abaxially; calyx tube 0.4 mm long; petals white, but purplish on the abaxial surface, ovate, 5.1–5.2 × ca. 3 mm, the apex acuminate, the margin membranous and entire, clawed at base, with two, slightly bulla-based hairs just below the apex on the abaxial surface, these 2–3 mm long; stamens twice the number of petals, the filaments 1.7–1.9 mm long, the anthers 1.4–1.5 mm long, with dorso-basal appendage and a single, dorsally inclined pore, the thecae 1.1 mm long. Style ca. 4.3 mm long, dilated at the center, with punctate stigma, subtended by a crown of long, multicelular hairs, these slightly longer than the surrounding bulla-based hairs on the apex of the ovary; ovary ca. 3.2 mm long, ca. 4.8 mm wide, fully inferior, 4-locular, placentation axile, placenta greatly intruded into the locules. **Berries** globose, ca. 5 mm long, ca. 6.5 mm wide, blue-black at maturity. **Seeds** (immature) ca. 0.9 mm long, sickle-shaped.

Distribution and habitat.—Miconia phrynosomaderma is only known from one gathering made in the Massif du Nord, at Morne Belle Terre, Artibonite Province, Haiti (Fig. 2). It was collected at 1050 m in elevation (*Ekman H8204*). Ekman in his field notes mentioned that Morne Belle Terre was built up of metamorphic rock, but no information regarding plant community at the elevation where *M. phrynosomaderma* was collected is known.

Phenology.—Miconia phrynosomaderma was in flower and mature fruit at the time of collection (May 22nd), so it is likely that the species begins flowering earlier in the year, but the flowering period is essentially unknown.

Etymology.—Miconia phrynosomaderma is named for the lizard genus *Phrynosoma* (Phrynosomatidae). The epidermis of *Phrynosoma* is covered in scales, which develop into horn-like projections, and thus members of the genus are commonly referred to as horned lizards. Bony outgrowths from the cranium also produce these horn-like structures (Fig. 3). The bulla-based hairs on the adaxial leaf surface of *M. phrynosomaderma* bear a striking similarity to the horned epidermis and bony crania of members of *Phrynosoma* (Presch 1969).

Based on morphological characters, *Miconia phrynosomaderma* appears to be most closely related to *M. limoides* and *M. lima*. *Miconia phrynosomaderma* differs from *M. limoides* by its sparse indumentum on the abaxial leaf surface and thus clearly visible abaxial epidermis, i.e., it is not completely covered by the indumentum (Fig. 1D–E), and by the spacing of the adaxial bulla-based hairs, i.e., they do not completely cover the leaf areoles (Fig. 1B–C). In *M. limoides* the bulla-based hairs completely obscure the abaxial lamina and completely

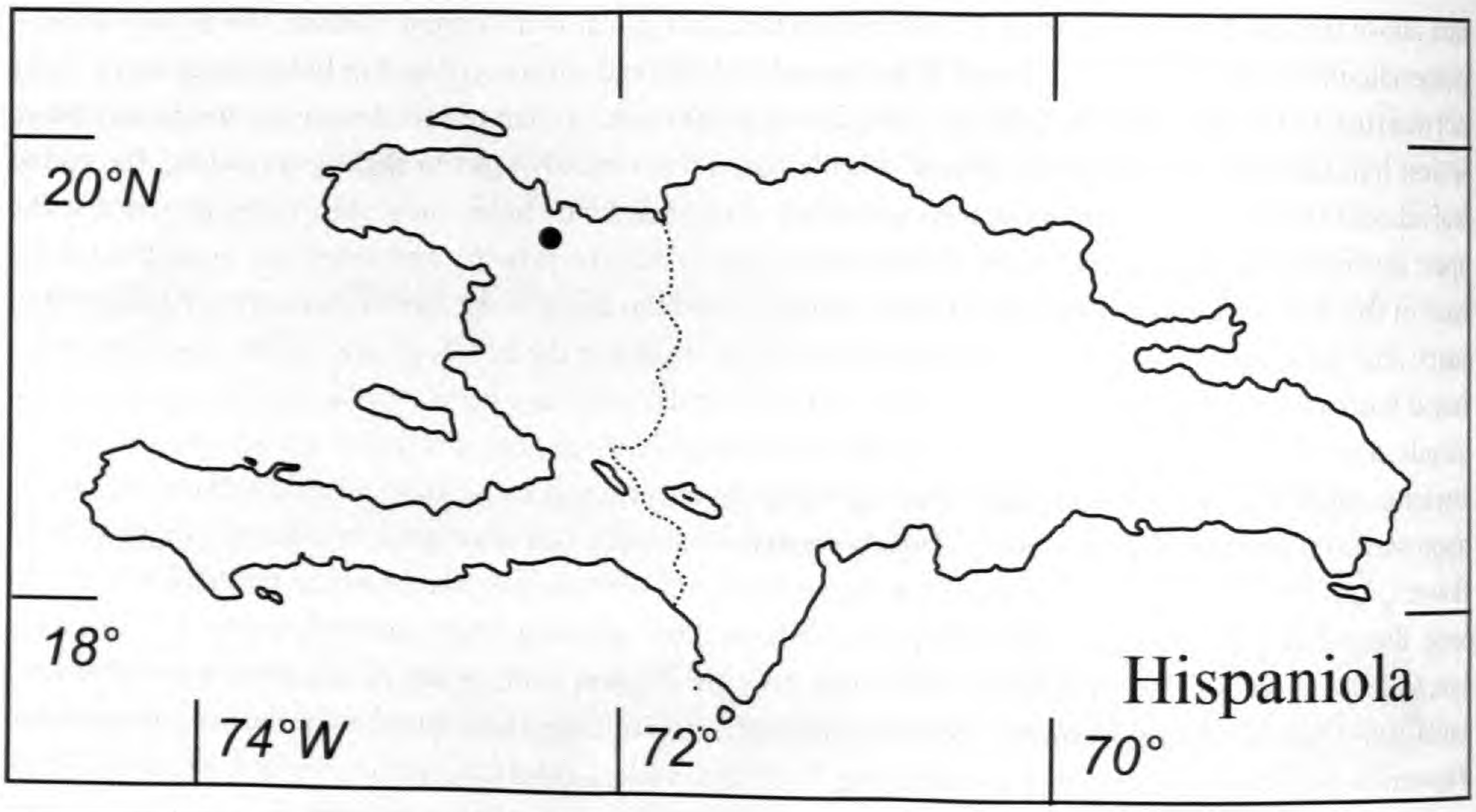


Fig. 2. Distribution of *Miconia phrynosomaderma* in northern Haiti.

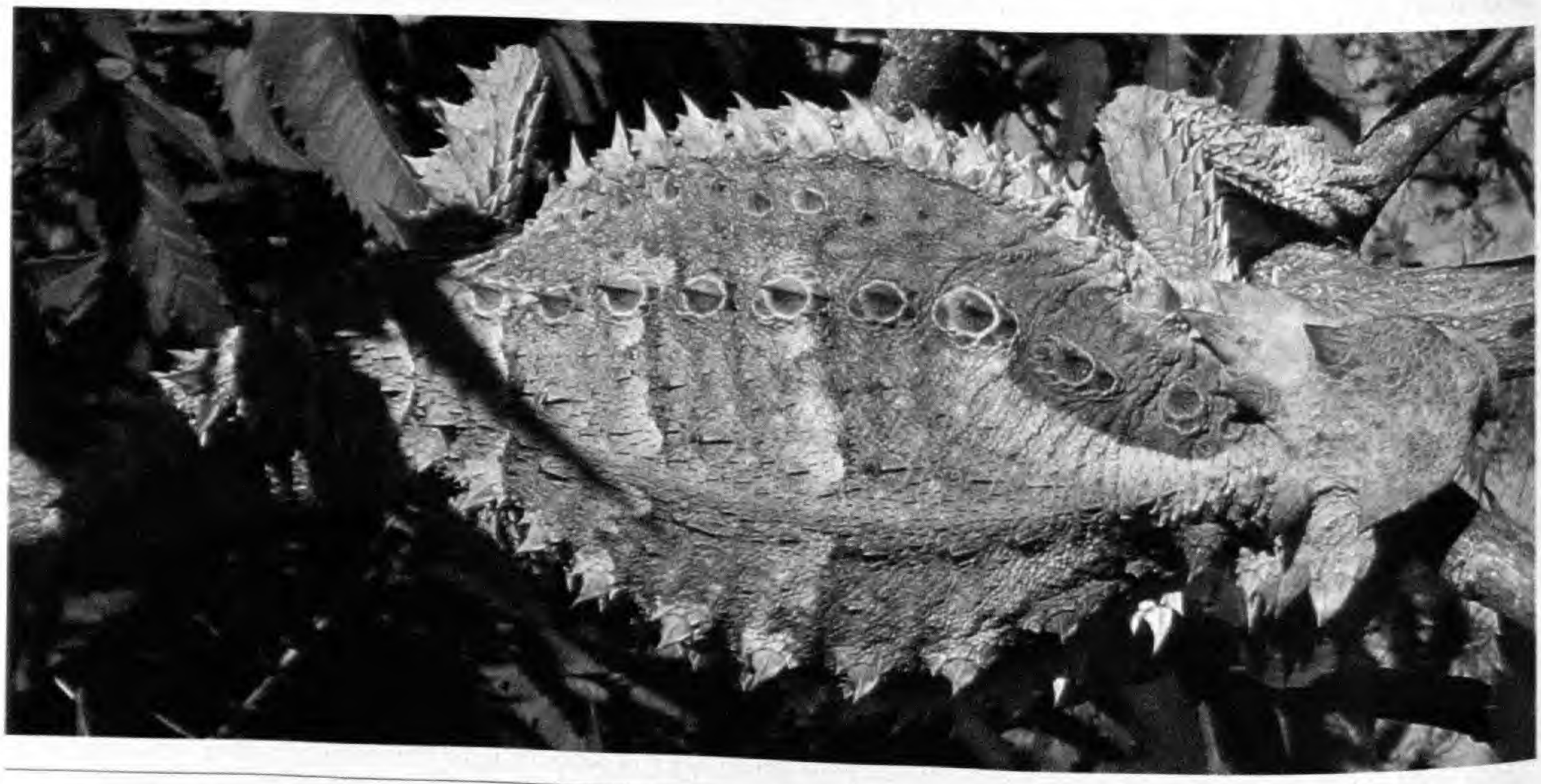


Fig. 3. *Phrynosoma taurus* Dugés hanging on to *Tecoma stans* (L.) Juss. ex Kunth in Chilpancingo, Mexico (photo by L.C. Majure).

fill the areoles. Stem hairs of *M. limoides* are mostly spreading to retrorse but not markedly appressed, while in *M. phrynosomaderma* they are mostly appressed-retrorse to slightly recurved at the tips. The ultimate dichasia of the inflorescences of *M. limoides* tend to be more condensed, i.e., flowers are mostly sessile to subsessile, than those of *M. phrynosomaderma*, which are more or less open with pedicellate flowers (Fig. 1A); however, this needs to be investigated further (with more collections of the latter). Also, the calyx teeth of *M. phrynosomaderma* are longer (i.e., 3.5–4.4 mm) than those of *M. limoides* (i.e., 2.1–3.3 mm). Finally, *M. phrynosomaderma* exhibits clawed petals and a dorso-basal appendage on the anther (Fig. 1G–I) to 0.3 mm long. *Miconia limoides* lacks clawed petals and has a reduced dorso-basal anther appendage to 0.1 mm long or it is entirely absent.

Miconia phrynosomaderma differs from *M. lima* by having stems with appressed-retrorse to recurved hairs vs. appressed-antrorse hairs (in *M. lima*), hypanthia 3.1–4 × 5 mm vs. 1.9–3 × 2.3–3.5 mm, and widely elliptical (length to width quotient 0.92–1.95) vs. narrowly elliptical (length to width quotient 1.56–2.05) leaves. *Miconia phrynosomaderma* differs from both *M. lima* and *M. limoides* by the purplish color of young leaves vs. the lime-green color in *M. lima* and *M. limoides*, as well as the color of the petals, that is, white with purple abaxial surfaces in *M. phrynosomaderma* vs. usually rose to red in *M. lima* and *M. limoides*. *Miconia limoides* may sometimes have white petals, but these are not purple abaxially. Also, both *M. limoides* and *M. lima* usually have an androecial fringe on the apex of the free portion of the hypanthium, which is a continuation of the hairs produced on the free portion of the hypanthium, but this structure is absent in *M. prhynosomaderma*.

Miconia phrynosomaderma satisfies the morphological-phenetic (Judd 2007) and diagnostic species concepts (Wheeler & Platnick 2000), as it is easily distinguished, morphologically, from its putative closest relatives, *M. limoides* and *M. lima*. *Miconia phrynosomaderma* also is allopatric from other members of the *Lima* clade, and so is most likely reproductively isolated from other species, thus satisfying the biological species concept (Mayr 1970, 2000). Finally, the clawed petals are likely autapomorphic, and thus *M. phyrnosomaderma* is most probably a cladospecies (Donoghue 1985; Mishler 1985).

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CRATAEGUS TENUIOR (ROSACEAE)—AN INTRIGUING NEW SPECIES FROM THE OKANAGAN OF BRITISH COLUMBIA AND WASHINGTON AND A NEW VARIETY OF *C. OKANAGANENSIS*

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ABSTRACT

The intriguing, red-fruited **Crataegus tenuior** has been known to the author for nearly 20 years and is finally described. The general appearance of *C. tenuior* is of a small, rather delicate *C. macracantha* but it differs in possessing ± plane-sided nutlets, not a series *Macracanthae* character, conspicuously glandular leaf-teeth and variably glandular petioles, not normal characters of *C. macracantha*. From sympatric forms of the latter species it also differs in its bright pink anthers. Multivariate analysis used to clarify the distinction from sympatric *C. macracantha* also illuminates the regional variation of the latter species. A new variety of the purple-fruited *C. okanaganensis* (series *Purpureofructae*) is also described which has longer thorns, larger leaves, fewer stamens and much more copiously hairy inflorescences than the other varieties. **Crataegus okanaganensis** var. **longispina** is described and illustrated.

KEY WORDS: *Crataegus tenuior*, new species, series *Macracanthae*, Rosaceae, British Columbia, Okanagan-Shuswap, Washington; *Crataegus okanaganensis* var. *longispina*, var. nov.

RESUMEN

El sorprendente **Crataegus tenuior** de frutos rojos ha sido conocido por el autor durante cerca de 20 años y es descrito finalmente. El aspecto general de *C. tenuior* es el de un pequeño y bastante delicado *C. macracantha* pero se diferencia por tener núculas con laterales ± planos, que no es un carácter de la serie *Macracanthae*, dientes de las hojas claramente glandulares y pecíolos variablemente glandulares, que no son caracteres normales de *C. macracantha*. También se diferencia de las formas simpátricas de esa especie por sus anteras rosa brillante. Se realizó un análisis multivariante para clarificar la distinción de los *C. macracantha* simpátricos que muestra la variación regional de esta última especie. También se describe una nueva variedad de frutos púrpura*C. okanaganensis* (series *Purpureofructae*) que tiene espinas más largas, hojas más grandes, menos estambres e inflorescencias mucho más pelosas que las otras variedades. Se describe e ilustra **Crataegus okanaganensis** var. **longispina**.

INTRODUCTION

Review of my accumulated duplicate collection prior to its recent dispersal revealed unfinished business in the taxonomy of Pacific Northwest *Crataegus*. The *Crataegus* described for that region can be divided into red-fruited or purple- to black-fruited groups based on color of their fully ripe fruit and both are represented in this paper. This paper describes *Crataegus tenuior*, sp. nov. (red-fruited), and *C. okanaganensis* var. *longispina*, new var. (purple-fruited), ensuring that the very rich variation encountered by the author in the general area of the British Columbia Okanagan is fully accounted for, at least as far as distinctive and repeatedly occurring forms is concerned.

CRATAEGUS TENUIOR

The red-fruited *Crataegi* of the Pacific Northwest were revised by Phipps (1998) with the species native to the Okanagan being in two series, ser. *Rotundifoliae* and ser. *Macracanthae*. The former contains *Crataegus chrysocarpa* and *C. sheila-phippsiae* and was revised for the region by Phipps and O'Kennon (2004). It is distinguished by plane-sided nutlets and glandular petioles. Series *Macracanthae*, with laterally pitted nutlets and eglandular petioles, is here represented only by *C. macracantha*. *Crataegus chrysocarpa* and *C. macracantha* are very wide-ranging species occurring from the Okanagan to the Atlantic.

The new species, *C. tenuior*, is local and, at first glance, very similar to the slender form of *C. macracantha* Lodd. ex Loud. var. *occidentalis* (Britt.) Kruschke. *Crataegus macracantha* var. *occidentalis*, with white anthers,

is the most usual form of *C. macracantha* west of the Rockies and is the only variety of the species so far recorded from British Columbia. *Crataegus tenuior* was first collected by myself and R.J. O'Kennon of BRIT in September 1993 in the Shuswap area of British Columbia but, in spite of the similarities alluded to above, several differences from *C. macracantha* var. *occidentalis* soon became apparent. These included: often more rounded leaf apices, generally smaller and less coriaceous leaves, small pink anthers, generally more slender thorns, and more delicate plant habit (Figs. 10, 11, 12). Moreover, *C. tenuior*, like *C. chrysocarpa*, but unlike *C. macracantha*, has the sides of the nutlets ± plane or, occasionally, only irregularly and shallowly pitted, as well as glandular, sometimes strongly so, petioles. In addition, *C. tenuior* shares with sympatric forms of both *C. macracantha* var. *occidentalis* and *C. chrysocarpa* Ashe var. *chrysocarpa*, the most common form of the latter species, the trait of ripening fruit passing through an apricot to salmon or orange phase on the way to ripening to a bright red (see *C. macracantha* - Figs. 13a, 12b), different from most other forms of both species, particularly those to the east of the Rockies, the fruit of which normally changes directly from green to red. However, in spite of sharing important characteristics with *C. chrysocarpa*, it is with a slender form of *C. macracantha* (Fig. 12b), sympatric with *C. tenuior*, that *C. tenuior* is most easily confused.

Crataegus tenuior proves to have a quite limited distribution predominantly in the northern Okanagan of southern British Columbia, mainly from somewhat north of Armstrong to the vicinity of Enderby in the north central Shuswap area where it is locally common. From this region it extends thinly into the generally drier Okanogan of Washington where *Crataegus* as a whole peters out. Mainly collected in the mid 1990s and 2002, *C. tenuior* remained undescribed until now because of the need to assess *C. macracantha* throughout its large range, the greatest of any North American *Crataegus*, prior to deciding whether it should be included in that species. Although *C. macracantha* has proven to be very variable through much of its range, especially so in Quebec and Montana, it has, except for a population in northwest Montana, strikingly eglandular petioles, a trait usually thought of as species-specific. Consequently, a morphometric study of relevant Pacific Northwest material was conducted to investigate these distinctions.

Morphometric study.—Fourteen flowering OTUs and 54 fruiting OTUs (Table 1), constituting all the former UWO (now TRT) specimens of putative *Crataegus tenuior* and *C. macracantha* from British Columbia and Washington, were used. The flowering specimens were scored for seven characteristics: mean length of three largest leaves, petiole glandularity (Figs. 9a, 9c), median thorn length, median thorn thickness, sepal margin serration (Figs. 9b, 9d), anther color (Fig. 11), and style number. The fruiting specimens used the same characters except that nutlet number replaced style number (it is usually the same) and nutlet lateral pitting replaced anther color. Missing data, if in less than 10% of OTUs, was replaced by column (character) means of the largest subset of OTUs considered, *a posteriori*, unequivocally the same taxon; if more than 10% missing that character would be rejected. Standard ordinations and cluster analyses were performed using Podani's SYN-TAX 2000. The data sets were ranged before analysis. The results are as follows:

i) Flowering material.

Cluster analyses of the euclidean distance matrix were by UPGMA (Fig. 1), complete link (CL, not shown), single link (SL, not shown) and incremental sum of squares, ISS (Fig. 2), thereby using some very contrasted methods. All show two major groups of seven OTUs each, these being *Crataegus tenuior* (OTUs 1–7, left) and *C. macracantha* (OTUs 8–14, right). UPGMA and CL are topologically identical. The SL result is topologically very similar to that for UPGMA while the very different-appearing ISS is topologically identical to UPGMA within *C. tenuior* but differs somewhat within *C. macracantha*.

The ordinations PoCA (Fig. 3) and MDS (Fig. 4) of the euclidean distance matrix similarly separate *Crataegus tenuior* and *C. macracantha* cleanly. The first axis of the principal co-ordinates analysis is responsible for 62% of the variation.

All six analyses of the flowering specimens sharply separate the same two groups, with one group always comprising seven specimens attributed to *Crataegus tenuior* and the other seven to *C. macracantha*. Although the sample size (n=14) is small, the concordance of very different methods emphasizes the robustness of the separation.

TABLE 1. Conciliation of OTU numbering in Figs. 1–8 with collection numbers. Collection numbers in parentheses. Collection numbers are all JBP numbers except 'Z'= P. Zika, 'WP'=Wm Phipps, and 'TCB'=TCBrayshaw. For *Crataegus tenuior*, most of these specimens may be found among those cited, though not for *C. macracantha*.

Flowering specimens: 1 (6913), 2 (6918), 3 (6923), 4 (8370), 5 (8389), 6 (8400), 7 (8401), 8 (6902), 9 (6903), 10 (6963), 11 (8304), 12 (8306), 13 (8420), 14 (8421).

Fruiting specimens: 1 (6811), 2 (6814), 3 (6814a), 4 (7011), 5 (7013), 6 (7171), 7 (8265), 8 (8274), 9 (8451), 10 (8452), 11 (8453), 12 (8454), 13 (8470), 14 (8471), 15 (8472), 16 (8474), 17 (6782), 18 (6792), 19 (8275), 20 (8473), 21 (6484), 22 (7103), 23 (7025), 24 (6783), 25 (8457), 26 (6778), 27 (6802), 28 (WP1.5), 29 (8456), 30 (6794), 31 (6790), 32 (6781), 33 (6787), 34 (6793), 35 (8176), 36 (6782), 37 (8275a), 38 (6976), 39 (6786), 40 (6779), 41 (8477), 42 (TCB4041), 43 (8463), 44 (8464), 45 (8478), 46 (6789), 47 (6867), 48 (6871), 49 (Z17891), 50 (Z17907), 51 (Z20320), 52 (17904), 53 (Z22423), 54 (7265).

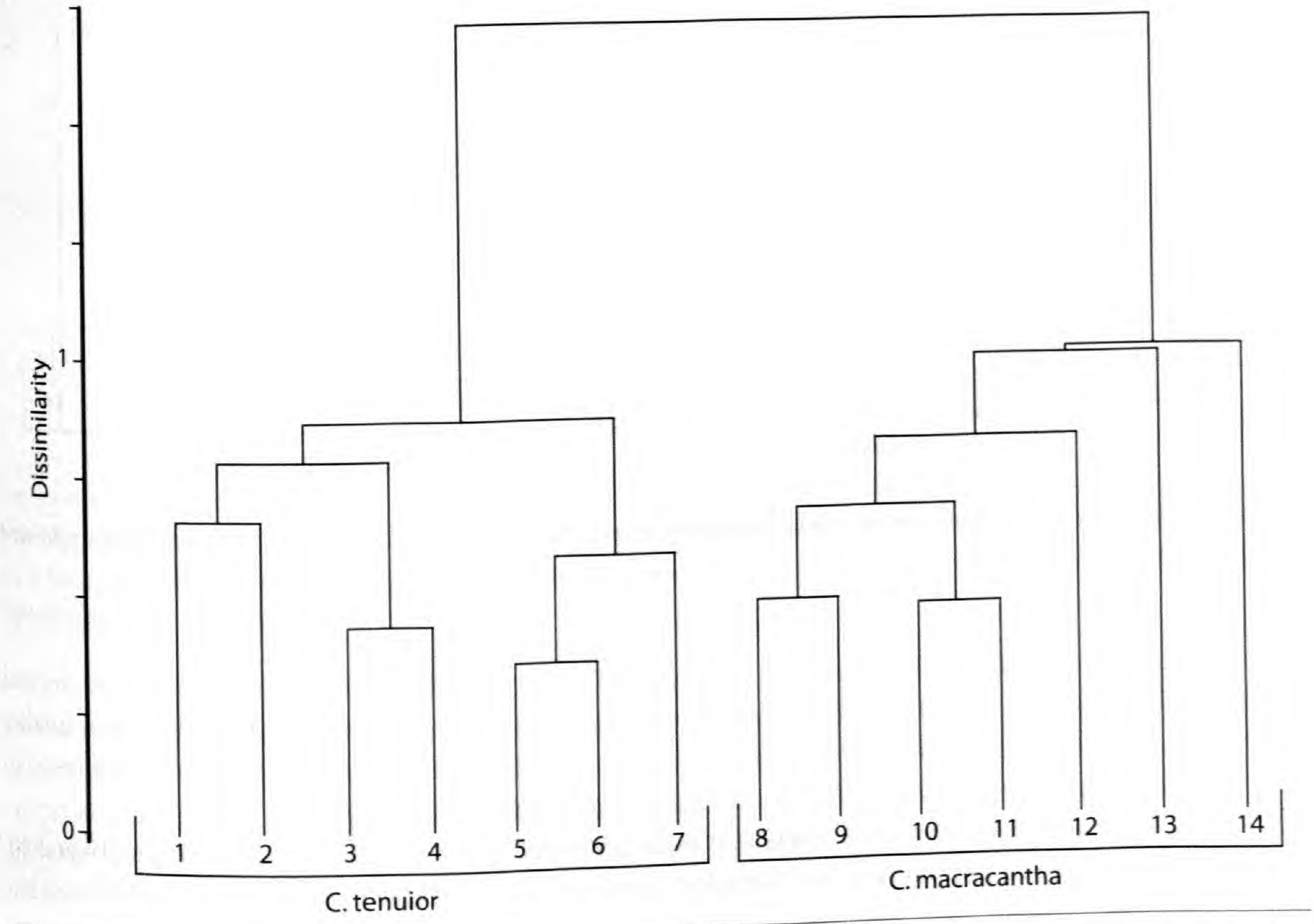


FIG. 1. UPGMA clustering of euclidean distance matrix of 14 flowering specimens of series *Macracanthae*. Left-hand group is *Crataegus tenuior* and right-hand group is *C. macracantha*.

The *Crataegus tenuior* OTUs all had pink anthers, ± entire to denticulate sepal margins, 3 or 4 styles, short thorns (mean = 40.14 mm) and short leaves (mean = 41.66 mm) while *C. macracantha* var. *occidentalis* OTUs had white or ivory anthers, more deeply serrate sepal margins, 2 or 3 styles, short to longer (mean = 51.4 mm) thorns and short to longer leaves (mean = 47.00 mm).

ii) Fruiting material.

The same four methods of cluster analysis were applied to the much larger sample of fruiting data (n=54). UPGMA (Fig. 5) finds a left-hand cluster of OTUs 1–16 plus 19 and 26, to which is added the very isolated 54, and a much larger right-hand group. There is also an extreme isolani (OTU 22) in Figure 5 which is the most isolated OTU of all and adds on after fusion of the two larger groups. CL, not shown, identifies the same left-hand cluster of OTUs 1–16 plus 19 and 26, with the remaining OTUs clustering in two fairly large groups with several specimens apparently even more isolated than OTUs 22 and 54. SL, also not shown, is very similar to the

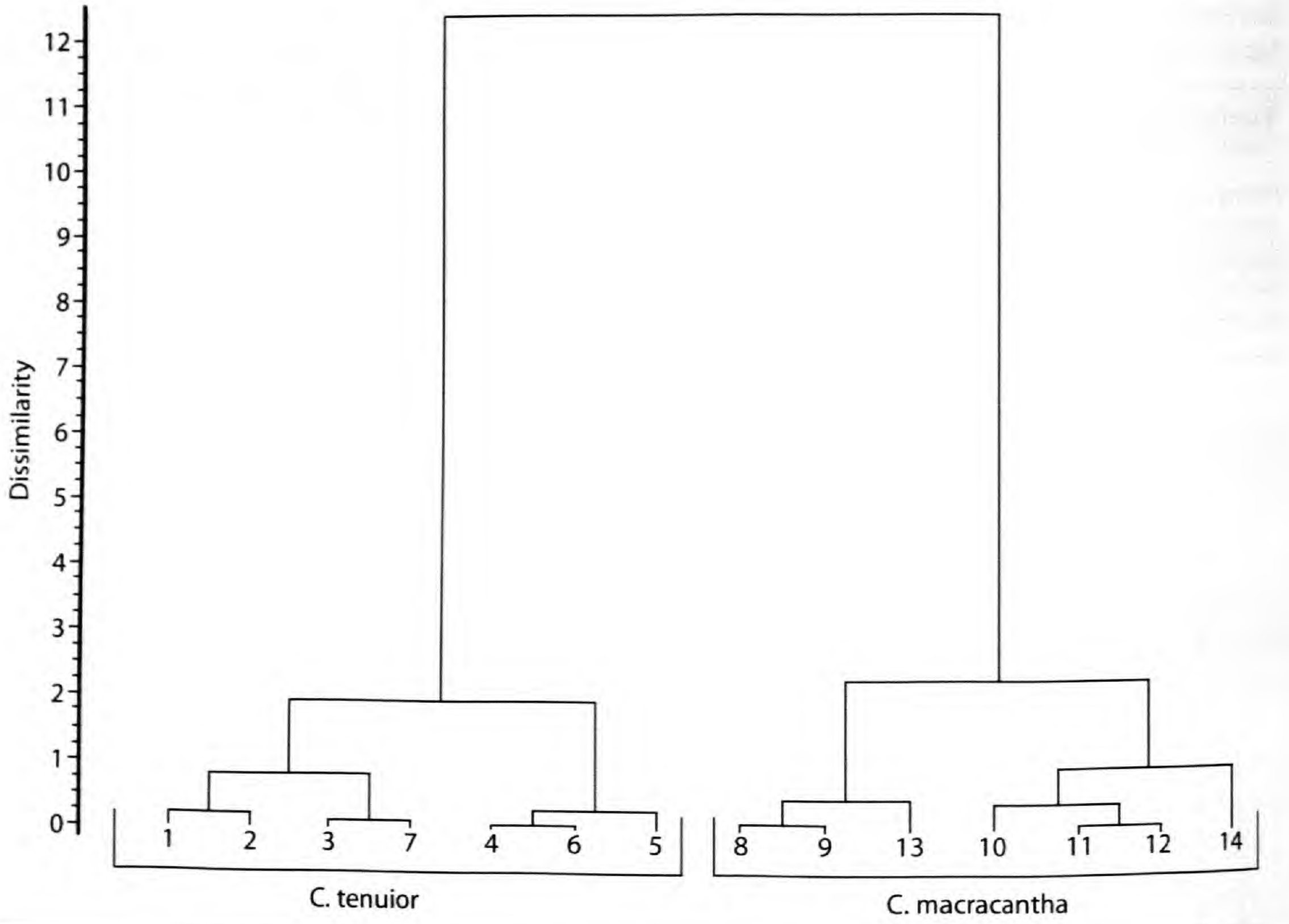


Fig. 2. ISS clustering of euclidean distance matrix of 14 flowering specimens of series *Macracanthae*. Left-hand group is *Crataegus tenuior* and right-hand group is *C. macracantha*.

UPGMA except that its left-hand group also includes OTU 39 and the large right-hand group lacks several OTUs which are added only after the fusion of the two big groups. Here also OTU 22 is added last, further emphasizing its isolated position. Finally, ISS (Fig. 6) divides all 54 OTUs into a left-hand group identical to that in UPGMA and the remainder. In this, as in CL, OTU 22 is not as isolated as OTU 54.

Summarizing the cluster analyses, there is a consistently occurring group of OTUs 1–16 plus 19 and 26. At least the great majority of these may be referred to *Crataegus tenuior* as they lack, or occasionally have a low level of nutlet pitting or scarring. Similarly, the remainder, comprising a large right-hand group, outliers, if any, to the left-hand group of *C. tenuior*, plus outliers, if any, to the combined main groups, may in large part be referred to *C. macracantha* as they have higher scores for nutlet pitting. OTUs 22 and 54 are notable outliers in the dendrograms.

Among the ordinations, PCoA (Fig. 7) yields a left-hand group of OTUs 1–16 plus 19 and 22 and a large group of the remainder. Here 41% of total variation is picked up by the first axis. MDS (Fig. 8) yields a top-right group of OTUs 1–16 plus 19 with OTU 22 by itself at top left and a bottom-left group of the remainder. In this OTUs 26 and 54 are peripheral. This strong isolation of OTU 22 in MDS reflects the UPGMA situation. As with the cluster analyses, a discrete *Crataegus tenuior* group may be found that is characterized by a lack of, or at most, a low level of, nutlet pitting or scarring. And as in the flowering analyses, all the OTUs with four nutlets lie in the putative *tenuior* group except for the isolated OTUs 22 and 54. Significantly, the two very different ordination methods identify the same main patterns of variation and also detect very similar groups to those of the cluster analyses with some inconsistencies regarding OTUs 22 and 26. The fruiting analyses are thus somewhat less mutually similar than the flowering analyses, an observation in line with the lower percentage of variance accounted for by axis 1 of the PCoA.

In all the fruiting analyses *Crataegus tenuior* occurs as a similar core grouping of OTUs 1–16 + 19. In these

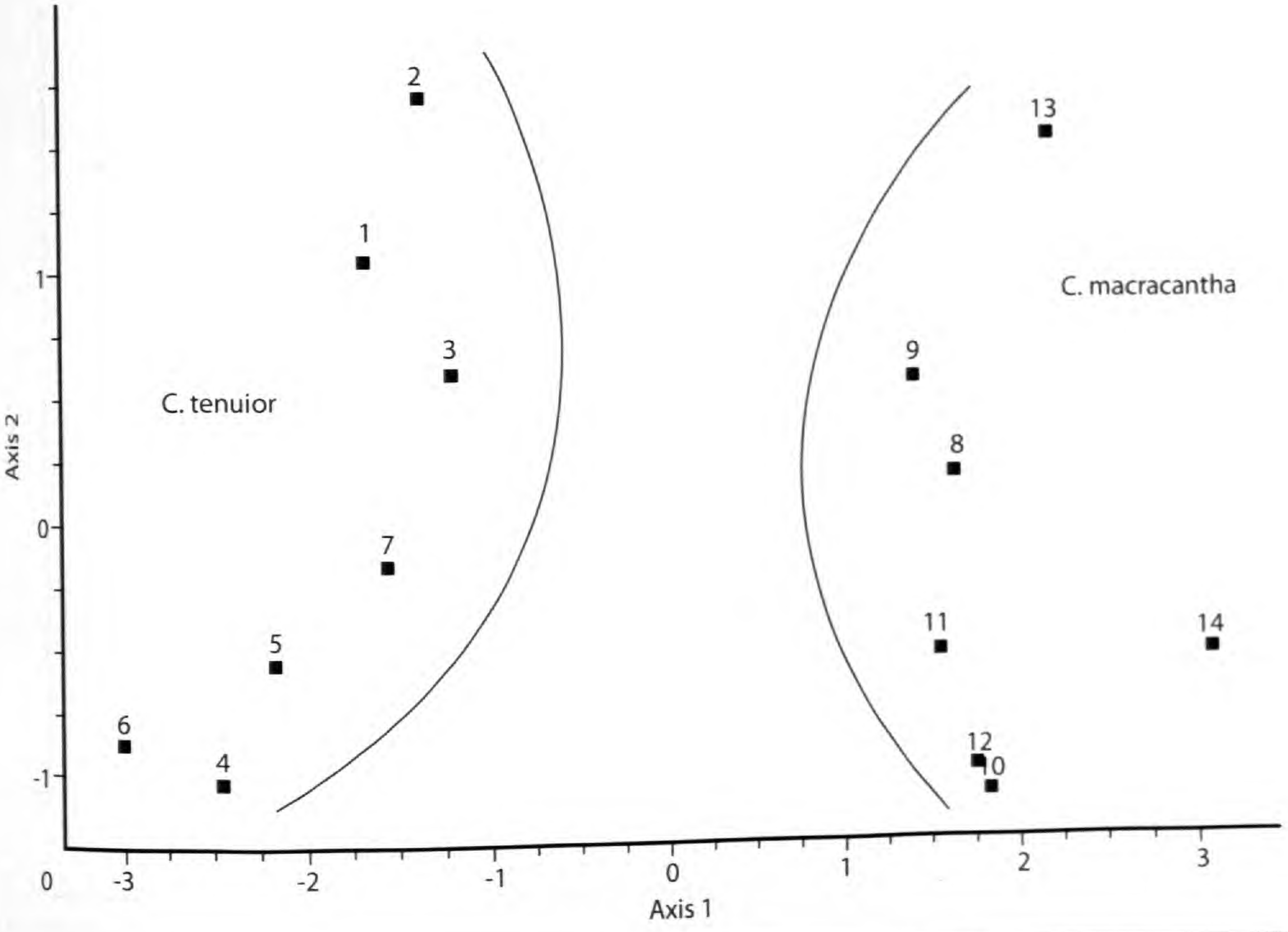


Fig. 3. Standardized PCoA of euclidean distance matrix of 14 flowering specimens of series *Macracanthae*. Left-hand group is *Crataegus tenuior* and right-hand group is *C. macracantha*.

analyses, the core *tenuior* group contains those specimens with plane-sided or nearly plane-sided nutlets (scores of 0–1 on a three-point scale), glandular petioles, subentire to barely serrate sepal margins where this character could still be reliably interpreted in fruit, and short thorns. In UPGMA (Fig. 5) the core *tenuior* group splits into three subgroups containing: OTUs 4, 5, 7, 9, 13; OTUs 1, 2, 3, 6, 8, 11, 12, 14, 15; and OTUs 10, 16, 19, the first and last of which have higher petiole glandularity than the second subgroup though the significance of this is not clear. Similar subgroups are found in Figure 6 (ISS) and they may also be detected in the ordinations (Figs. 7, 8). It is, of course, a feature of glands that they may be subject to abrasion through the season so what may be a more constant character at anthesis can be less well-defined later. OTU 19 is the only specimen grouping with the *tenuior* core that has a middling nutlet score (1.75) so is not entirely typical.

Crataegus macracantha is represented by all of the remaining OTUs (17–18, 20–54) in the fruiting analyses except OTU 22, see below, interpretation. All the OTUs in the 17–18, 20–54 *macracantha* group, plus OTU 22, have nutlet sides significantly (score of 2) to strongly (score of 3) pitted, except for OTUs 26, 27 and 54 which have middling nutlet side scores (respectively 1.25, 1.75, 1.5). OTUs 26 and 39 are 'floaters' that may sometimes cluster loosely with the core *tenuior* group though both ordinations place them in the *macracantha* group but in the part closest to the *tenuior* group. Within the *macracantha* group UPGMA (Fig. 5) has a left hand cluster containing OTUs 17, 18, 20, 21, 29, 30, 32, 34, 36, 48, 42, 53 that mainly comprises the smaller-leaved specimens with dimensions more like *C. tenuior*. The non-*tenuior* OTUs are arranged rather differently in the various analyses, a fact particularly seen in both the inconsistent positioning of more isolated OTUs and in the CL dendrogram that is not shown. A major reason for this is presumably that the fruiting sample is much larger than the flowering one (54 OTUs compared to 14), and therefore more diverse, this no doubt due to the much longer time-frame over which adequate specimens can be collected.

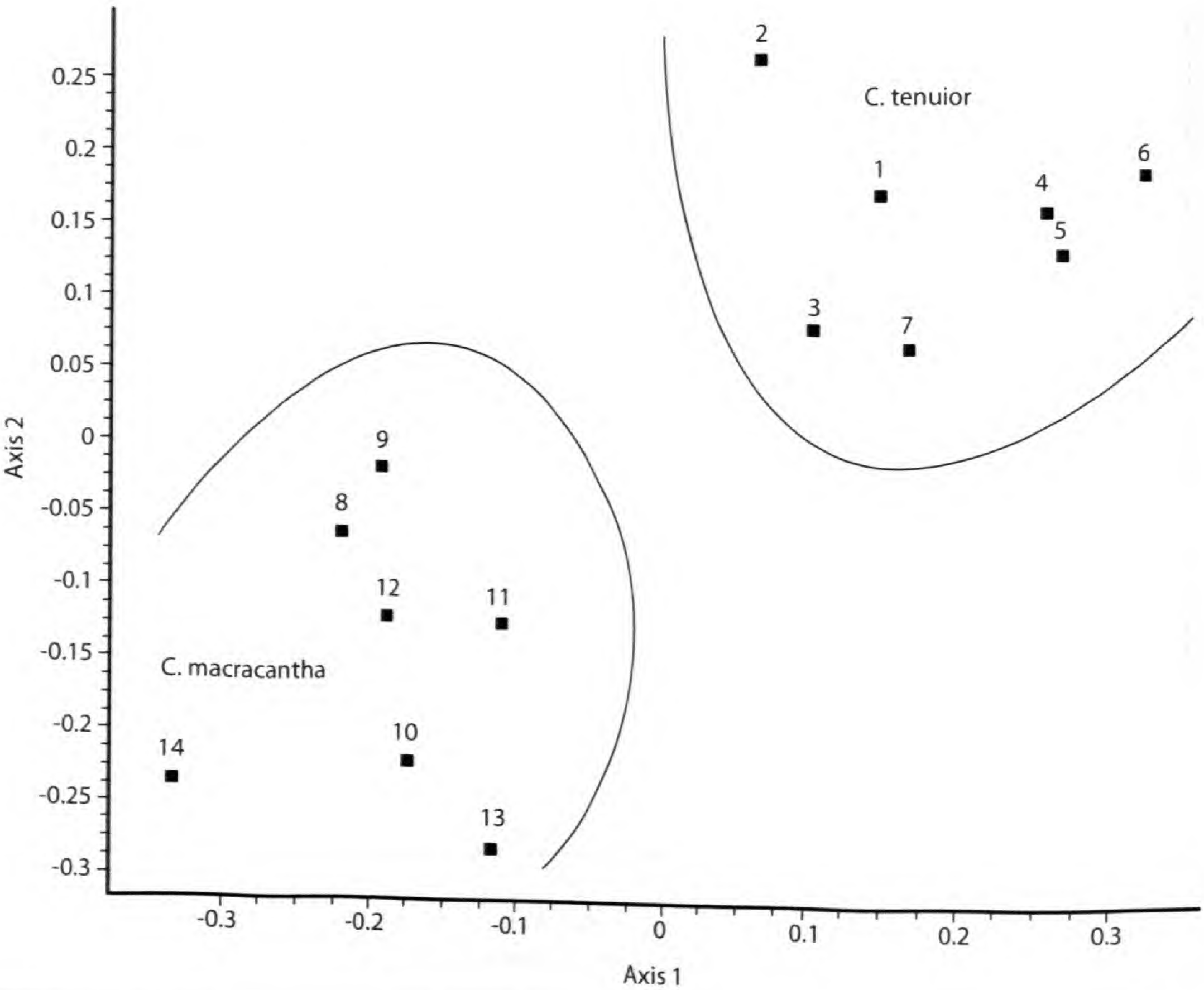


FIG. 4. Plot of MDS of euclidean distance matrix of 14 flowering specimens of series *Macracanthae*. Top-right group is *Crataegus tenuior* and bottom-left group is *C. macracantha*.

iii). Interpretation.

The flowering OTUs separate cleanly into two groups with clear character differences as mentioned above. However, in the more numerous fruiting OTUs more variation is present and two mutually exclusive groups do not emerge. Nevertheless, a group of 1–16 + 19 is consistently found which is *Crataegus tenuior*. In fruit, the best interpretation seems to be to accept the presence of plane-sided nutlets as decisive for this species and to consider petiole glandularity a more variable character that scores low to high in *tenuior* compared to nil (usually) or low in putative *macracantha*. As well, a few OTUs, e.g., fruiting 26, may be atypically intermediate or perhaps hybrid between the two main groups.

Whereas a *Crataegus tenuior* group may be readily recognized in the fruiting results, the non-*tenuior* OTUs display several problems with their lower level of cohesion. On the one hand, they suggest that there may be fundamental differences between large and small-leaved *macracantha*. However, the study was not set up to test this and, minimally, would have required a greater range of leaf characters to do so. Also, OTU 54 is an oddity, perhaps cultivated, from the post office at Mara, northern Okanagan. This is clearly a *C. macracantha* form with its eglandular petioles and pitted nutlets but it possesses a leaf shape differing from all other *macracantha* individuals in the study, as well as very villose parts, again quite unlike the others studied. Some of its more distinct features did not get measured in this study which has a different objective and furthermore, being thornless, it achieved thorns of mean length as is necessary for missing data in SYNTAX. Thus, OTU 54 is in actuality more distinct than the analyses show and perhaps represents a human import to its locality. It has resemblances to *C. macracantha* var. *pertomentosa* (Ashe) Kruschke. Quite different, however, from the main mass of *macracantha* is fruiting OTU 22 from Tonasket, Washington (Fig. 14). This individual appears the most

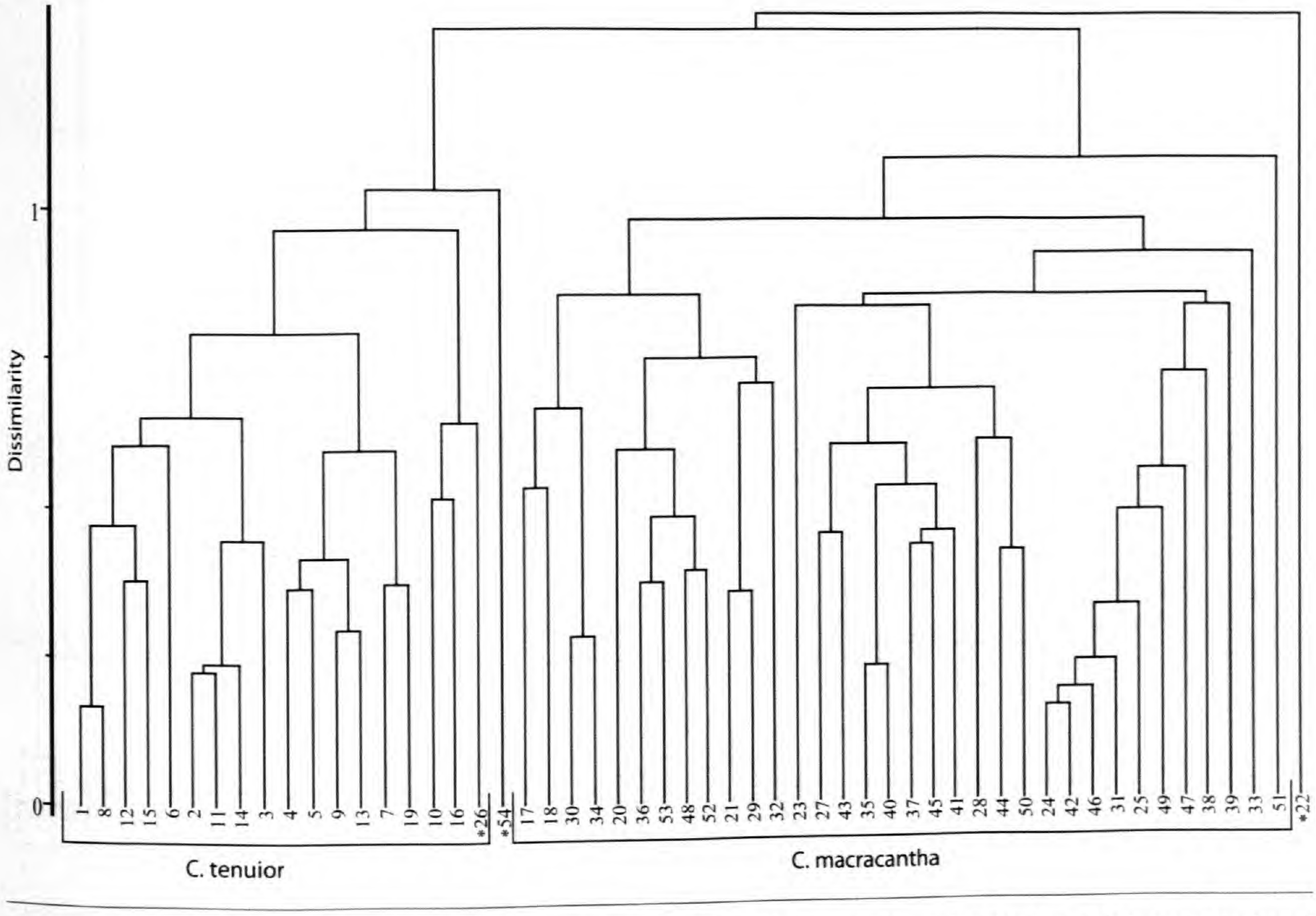


Fig. 5. UPGMA clustering of euclidean distance matrix of 54 fruiting specimens of series *Macracanthae*. Core of left-hand group is *Crataegus tenuior* and right-hand group is *C. macracantha*. OTUs 22, 26 and 54 are starred. Note isolation of OTU 22.

extreme of all in UPGMA and MDS, is second most extreme in ISS and is peripheral in PcoA. It is the only OTU in the study to combine four nutlets, highly glandular petioles, and deeply pitted nutlet sides. Unlike *C. tenuior*, it has essentially glandless leaf-teeth at ×10. Also, it is the only specimen of the 68 studied to have a distinctively non-macracanthoid leaf shape, one with clear resemblances to *C. chrysocarpa*. This, I suspect, is a very rare example in the study area, perhaps unique in collections, of an F_1 hybrid or clone thereof, between *C. chrysocarpa* and *C. macracantha* var. *occidentalis*.

Confirmation that the calibration of fruiting and flowering groups to taxonomic names is consistent is shown by two flowering specimens attributed to *Crataegus tenuior* (*JBP 6814* and *JBP 8401*) being from the same plants as *JBP 7171* and *JBP 8454* (fruiting) while for *C. macracantha* var. *occidentalis JBP 6903* (flowering) comes from the same plant as *JBP 6871* (fruiting).

Crataegus tenuior J.B. Phipps, sp. nov. (**Figs. 9–11**). TYPE: CANADA: BRITISH COLUMBIA: Okanagan, Shuswap valley, just E of Enderby, *JB Phipps 6913*, 5 May 1994 (HOLOTYPE: TRT; ISOTYPES: DAO, UBC, V, WTU).

Frutices, 2.5–4.0 m alti, multicaules; ramuli unius anni ± castanei vel rubrobrunnei, veteres cinereo-brunnei; spinae 3–5 cm longae, rectae vel leviter recurvatae, ± tenues, in juventute nitenter atrospadiceae. Folia decidua: petioli 1.25–2.5 mm longi, pubescentes solum in sulco, aliquando glandulomaculati; laminae (2.5–)3–5(–7) cm longae, late-ellipticae vel ovatae vel rhombovatae, apicibus subacutis, basibus ± late-cuneatis, vadositer 4–5(–6) lobatis per latus, lobis acutis vel obtusis, marginibus serratis, serris conspicue nigro-glandulosis (± integribus in parte tertia basali excepta), venatione craspedodroma, venis 5(–6) per latus, adaxialiter inconspicue impressis in maturitate, superficiebus adaxialibus dense et breviter appressis-villosis, superficiebus abaxialibus glabris, leviter pubescentibus per venas, textura tenui et colore autumnali luteo. Inflorescentiae ca. 10-floratae, ramulis tomentosis, bracteolis caducis, linearibus, membranaceis, glandulo-marginatis, glandibus subsessilibus. Flores 15–17 mm diam.; hypanthium extrinsecus dense pubescens; sepala anguste triangularia, marginibus ± glandulo-denticulatis, abaxialiter ± glabra; petala ± circularia, alba; stamina 5–10, antheris roseis, saepe parvis (ca. 0.6 mm); styli 3–4. Fructus ca. 8–10 mm diam., ± late ellipsoidales, in juventute aurantiaci, in maturitate clare coccinei, varie villosi, reliquis sepalorum ± appresso-patentibus; pyrenae 3(–4), dorsaliter sulcatae, lateribus ± planis vel irregulariter et vadositer erosis.

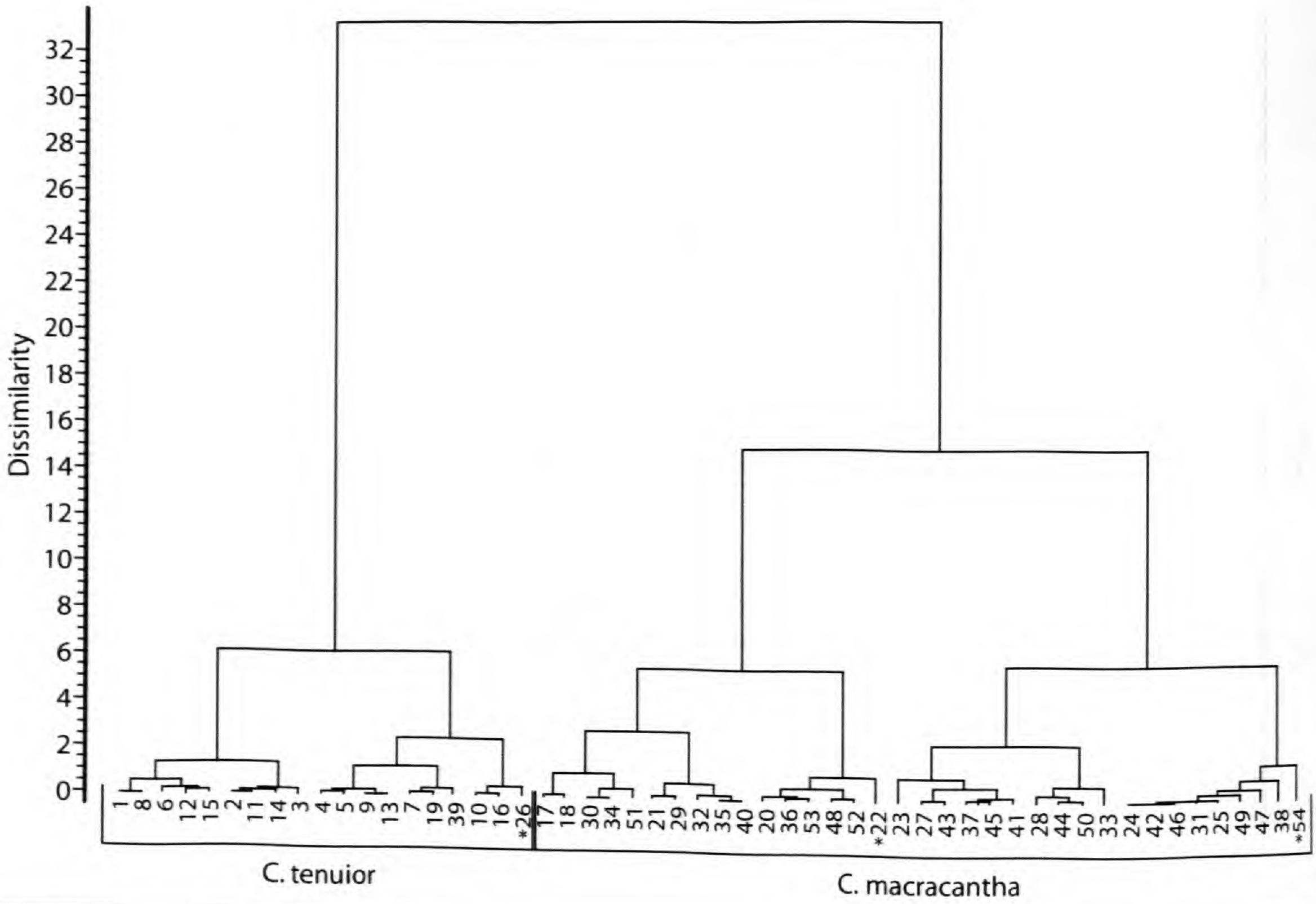


Fig. 6. ISS clustering of euclidean distance matrix of 54 fruiting specimens of series *Macracanthae*. Core of left-hand group is *Crataegus tenuior* and right-hand group is *C. macracantha* + OTU 22. OTUs 22, 26 and 54 are starred.

Bushes, 2.5–4.0 m tall, multi-stemmed: 1-year old twigs tan to reddish brown, older gray-brown; thorns 3–5 cm long, straight to slightly recurved, thinnish, glossy black-chestnut when young. Leaves deciduous; petioles 1.25–2.5 cm long, pubescent only in sulcus, variably gland-dotted; blades (2.5–)3–5(–7) cm long, broadly elliptic to ovate or rhombovate in general shape; apices subacute, bases broad-cuneate, shallowly 4–5(–6) lobed per side, lobes acute to obtuse; margins serrate, teeth with conspicuous black marginal glands (except ± entire in basal third), venation craspedodromous with 5(–6) pairs of lateral veins, veins adaxially not strikingly impressed at maturity, adaxially densely short-appressed hairy, abaxially thinly pubescent on the veins, otherwise glabrous, texture thin, autumnal color bright yellow. Inflorescences abt. 10-flowered; branches tomentose, bearing caducous, linear, membranous, gland-margined bracteoles, glands subsessile. Flowers 15–17 mm diam.; hypanthium externally densely pubescent; sepals narrow-triangular, margins ± glandular-denticulate, abaxially ± glabrous; petals ± circular, white; stamens 5–10, anthers pink, often small (ca. 0.6 mm); styles 3–4(–5). Fruit ca. 8–10 mm diam., ± broad-ellipsoid, orange when young, brilliant red at maturity, variably villous; calyx remnants present, ± appressed-spreading; nutlets 3(–4), dorsally furrowed, their faces ± plane or irregularly and shallowly eroded.

Crataegus tenuior is most easily distinguished in flower (Figs. 9, 11) when it differs from sympatric *C. macracantha* by a variety of characters as discussed above. In fruit, however, *C. tenuior* may be difficult to distinguish from smaller-leaved specimens of *C. macracantha* without dissection of the pomes. This is because the petiolar glandularity character has some overlap, the sepal margin character may be difficult to discern, the plane-sided nutlets, though shown by the numerical analyses to be definitive for the species, are not evident without dissection, and the nutlet number of three, most frequently found, is not diagnostic. At that stage, therefore, one may use for macroscopic identification specimens tagged at flowering time although autumnal leaf color (yellowish in *C. tenuior* vs. bronze in sympatric *C. macracantha*) makes for a helpful distinction, as

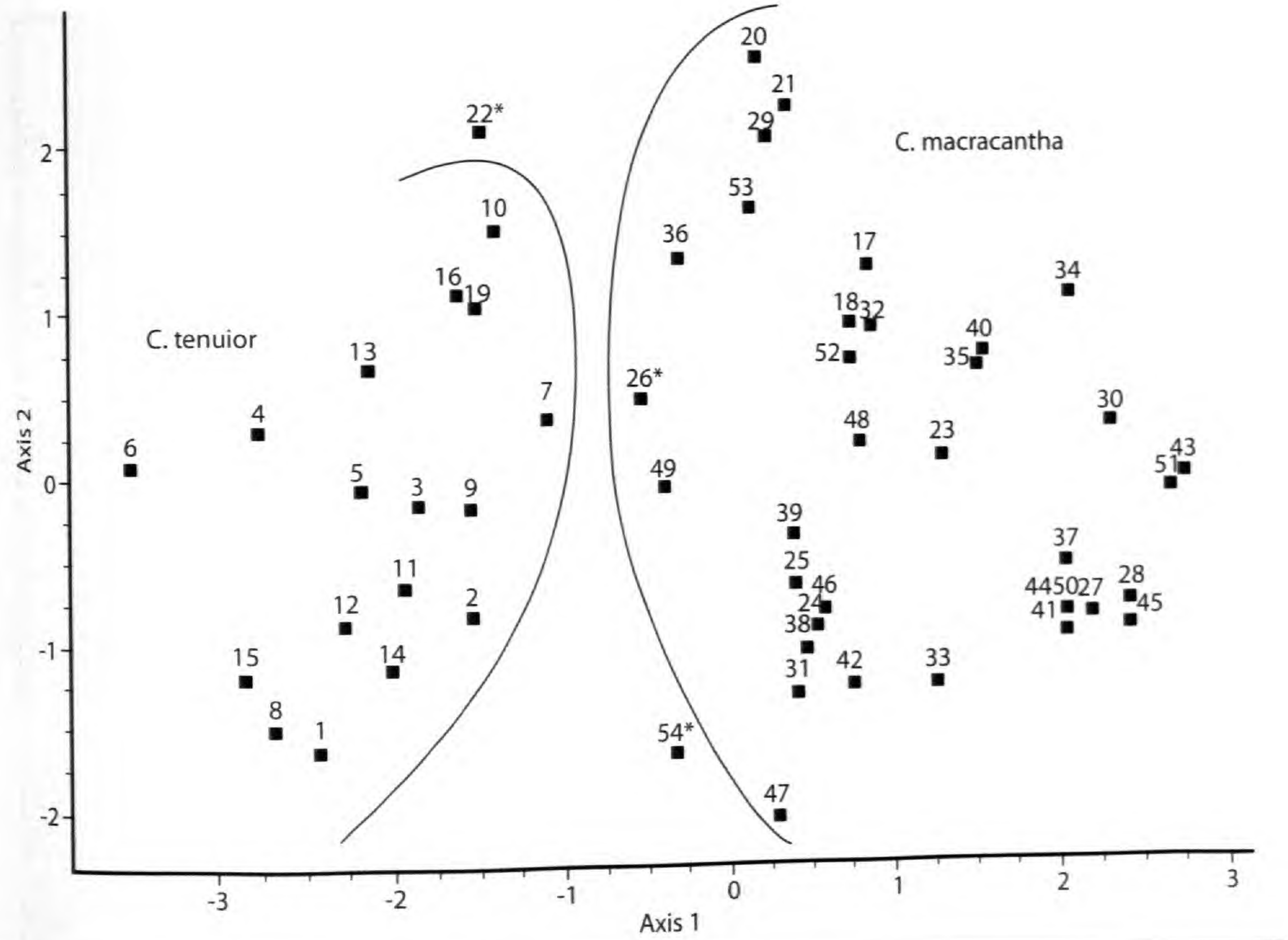


FIG. 7. Standardized PCoA of euclidean distance matrix of 54 fruiting specimens of series *Macracanthae*. Left-hand group is *Crataegus tenuior*; right-hand group is *C. macracantha*; OTUs 22, 54 excluded. OTUs 22, 26 and 54 are starred.

may the smaller leaves, and greater delicacy of habit, twig, thorn, and leaf texture with the more robust forms of *C. macracantha*. With regard to *C. chrysocarpa*, in spite of sharing several characters in common with *C. tenuior*, see key, it has such a different facies that it is easily separated macroscopically. The following key summarizes critical distinctions between *C. tenuior*, *C. macracantha* var. *occidentalis* and sympatric *C. chrysocarpa* var. *chrysocarpa* in the context of all the red-fruited *Crataegi* of the Okanagan. Note that with fruiting material it is best to check several fruits for nutlet pitting.

KEY TO RED-FRUITED *CRATAEGUS* SYMPATRIC WITH *C. TENUIOR*

1. Leaves deeply lobed, sometimes nearly to midrib; veins to sinuses; stamens 20, anthers pink-purple; styles and nutlets 1 ____ **C. monogyna**

1. Leaves shallowly lobed; veins to sinuses lacking; stamens usually 10, anthers cream or pink; styles and nutlets 2–4(–5).
   2. Autumnal leaf color usually bronze; petioles eglandular; stamens 10, anthers cream; sides of nutlets strongly pitted ____ **C. macracantha** var. **occidentalis**
   2. Autumnal leaf color usually yellow; petioles more or less glandular; stamens 10 or 20, anthers ivory (cream) to pink; sides of nutlets smooth. ____ **C. sheila-phippsiae**
      3. Stamens 20, anthers pale pink ____
      3. Stamens 10, anthers pink or ivory (cream).
         4. Plant habit lax; twigs in second year reddish-brown or deep reddish-brown; leaf-teeth with conspicuous (to a ×10 lens) glands; anthers pink; styles and nutlets 3(–4) ____ **C. tenuior**
         4. Plant habit stiff; twigs in second year ± fawn or grayish-fawn; leaf-teeth with very small (just visible with a ×10 lens) or no glands; anthers ivory; styles and nutlets 3–4(–5) ____ **C. chrysocarpa** var. **chrysocarpa**

Additional differences between *Crataegus tenuior* and *C. chrysocarpa* var. *chrysocarpa* exist in the form of the leaves. In fact, the two are normally distinguishable on this character alone with experience even though it is difficult to express this in words. Also, the latter taxon, being the most xeromorphic western *Crataegus*, can be

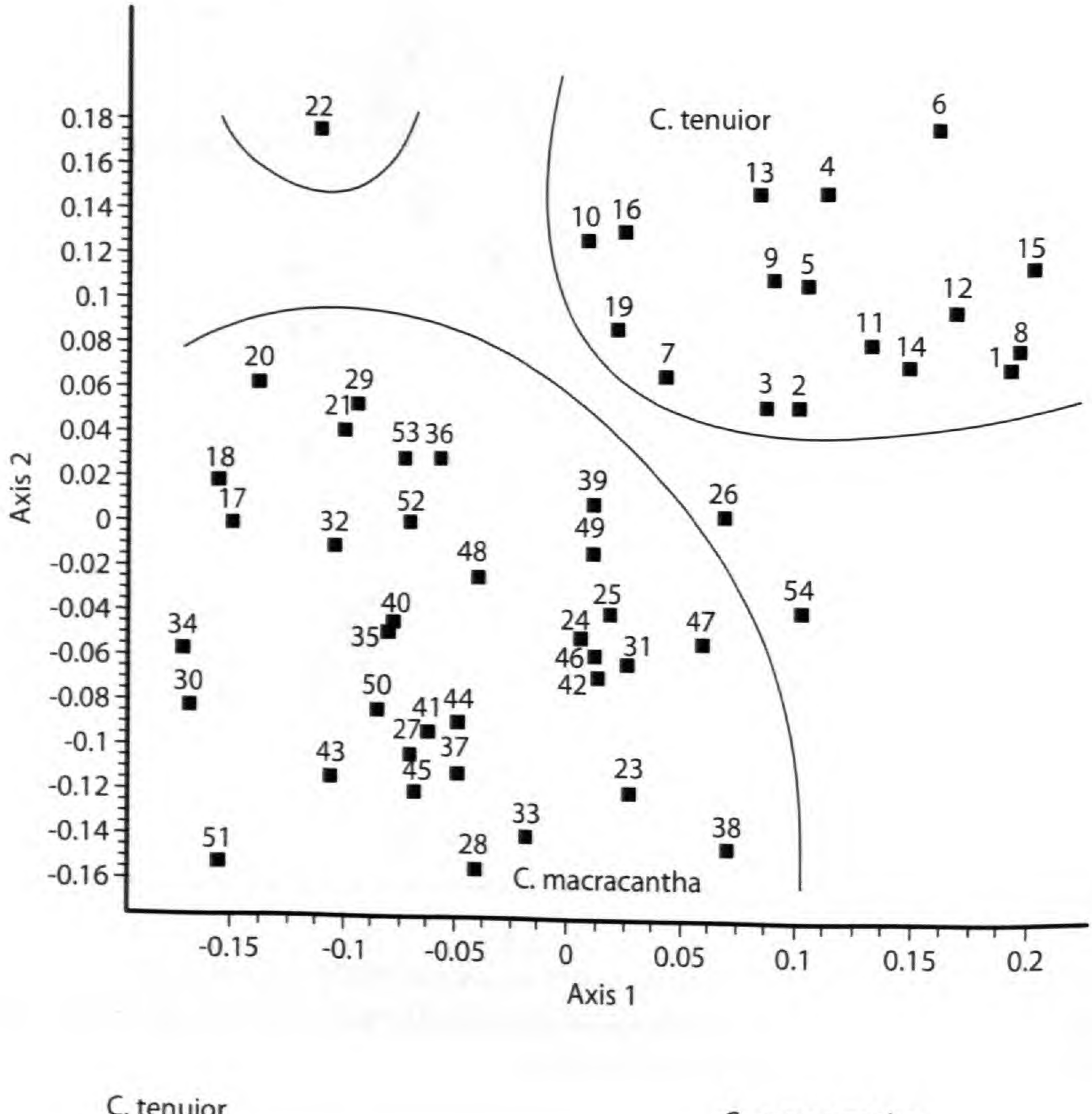


FIG. 8. Plot of MDS of euclidean distance matrix of 54 fruiting specimens of series *Macracanthae*. Upper right group is *Crataegus tenuior* and lower left group is *C. macracantha*. Note isolation of OTU 22.

found in drier habitats than *C. tenuior* even though there is much overlap. With regard to *C. macracantha var. occidentalis*, much more floriferous inflorescences and larger leaves may be found in many (Figs. 12, 13) than in *C. tenuior* (Figs. 9, 10), though again there is considerable overlap in these traits due to the frequent occurrence of smaller-leaved and smaller inflorescence forms of *C. macracantha*.

Relationships and possible origins.—*Crataegus tenuior* is a local species with obvious similarities to, and equally strong differences from, the very widespread *C. macracantha* so it is tempting to consider it of hybrid origin with that species. Further, being a red-fruited hawthorn whose fruit passes through the typical orange phase of most western *Crataegus* and possessing the plane-sided nutlets and glandular petioles of the equally common and also sympatric *C. chrysocarpa*, the latter is an another candidate parent especially as there are so few red-fruited native *Crataegi* in the area. However, *C. tenuior* possesses conspicuous (with a ×10 lens) gland-tipped leaf-teeth, as well as pink anthers, unlike either of *C. macracantha* or *C. chrysocarpa* from British Columbia or Washington. However, in spite of differing anthesis times, *C. macracantha* × *C. chrysocarpa* is the suggested origin for the sporadic *C. laurentiana* (Quebec, etc.), as well as a similar but more abundant, unnamed form in Minnesota, and perhaps the variable and recently resurrected *C. sheridana*, widespread in the Great Plains (Phipps & O'Kennon 2007). Still, it is notable that, in spite of the abundance and sympatry of *C. macracantha* and *C. chrysocarpa* in the greater Okanagan, apparent first or early generation hybrids are hardly ever seen, let alone collected (except perhaps OTU 22, this paper), This being so, the distinctive Okanagan en-

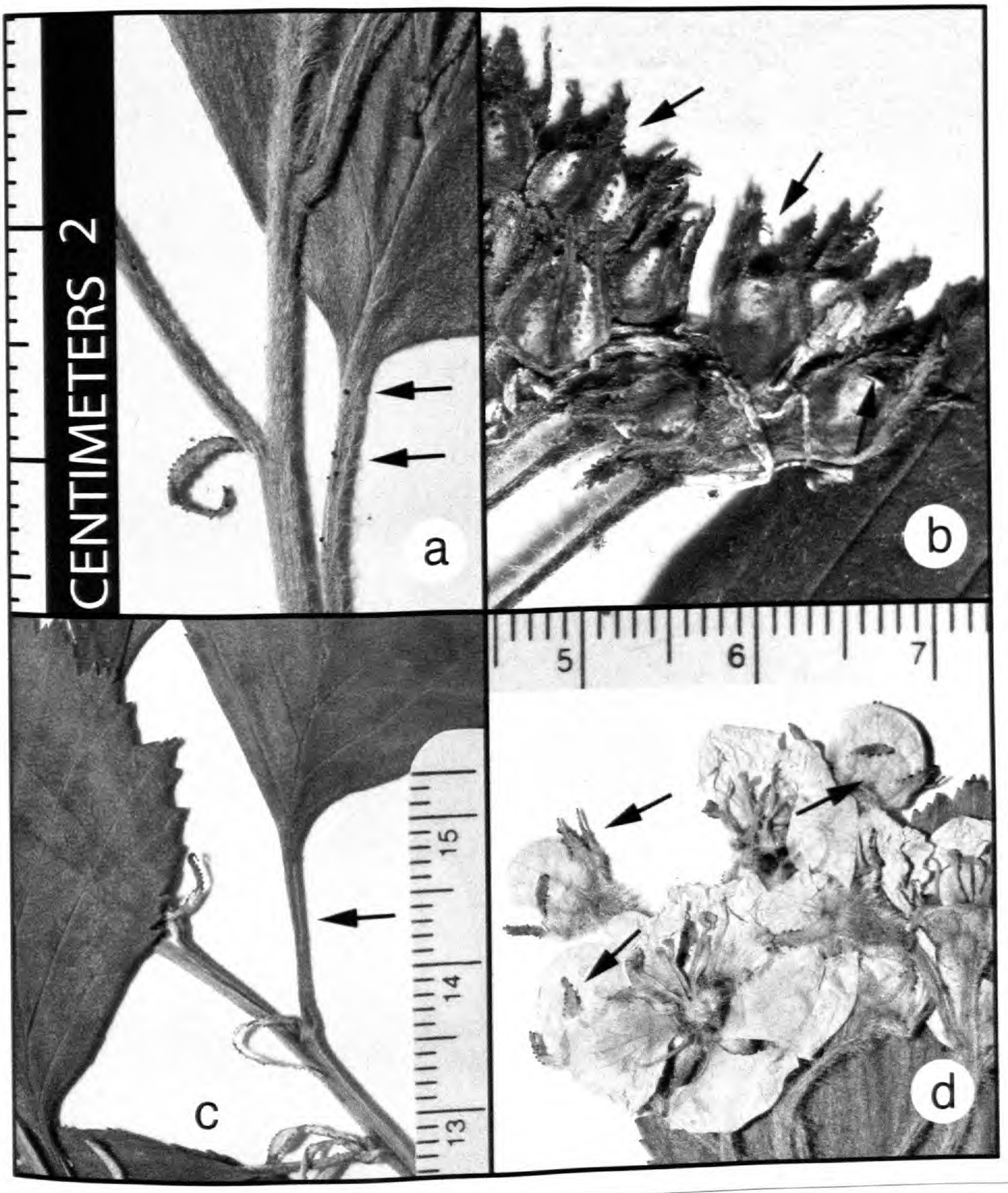


Fig. 9. Comparisons of petioles and inflorescences of *Crataegus tenuior* (*Phipps 6913*, holotype) and *C. macracantha* var. *occidentalis* (*Phipps 6902*); **a)** eglandular petioles of *C. macracantha*; **b)** deeply serrate sepal margins in *C. macracantha*; **c)** glandular petioles of *C. tenuior*; **d)** denticulate sepal margins in *C. tenuior*.

demic *C. atrovirens* (ser. *Purpureofructae*), which has pink anthers and the larger type of leaf marginal gland, could instead be considered a candidate parent. But *C. tenuior* shows no suggestion of the plump, ampulliform, purple, large-sepalled fruit of *C. atrovirens*. Also, the latter species is recorded as having pitted nutlets. Thus, in lack of precise intermediacy between any two sympatric taxa, adaptive radiation cannot be discounted as a mechanism of origin and resolution of the matter must await molecular study. In passing, one may speculate that the small-leaved form of *C. macracantha*, noted at the beginning and in discussion of the morphometric results, might represent introgression or hybrid origin between *C. tenuior* and the larger-leaved *C. macracantha* var. *occidentalis*.



Fig. 10. Part of holotype of *Crataegus tenuior* (*Phipps 6913*, nr. Enderby, British Columbia).



Fig. 11. Photographs of flowering specimens: **a)** *Crataegus tenuior* (*Phipps & O'Kennon 8370*); note pink anthers; **b)** *C. macracantha* (*Phipps 6963*); note cream anthers, larger inflorescence.

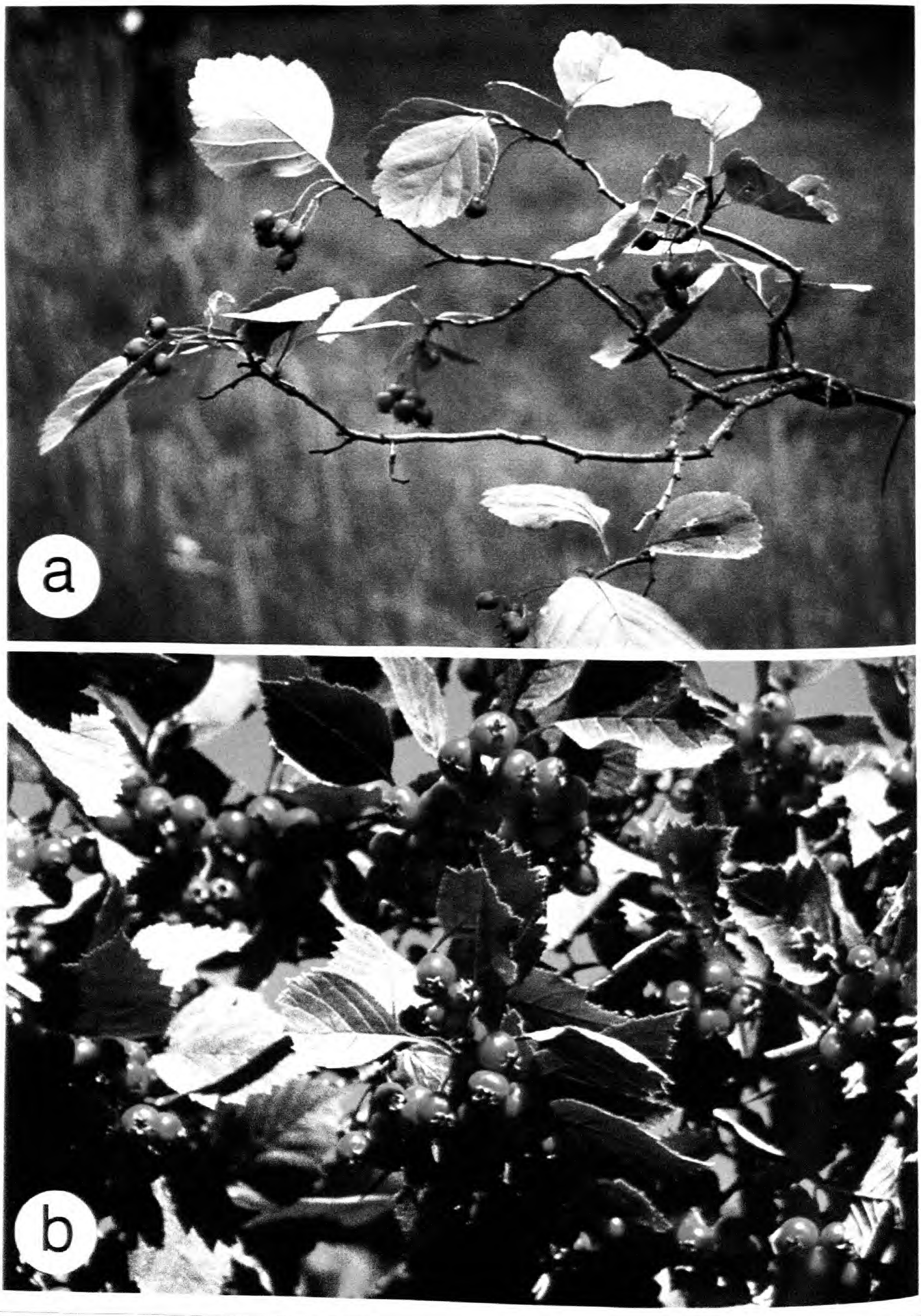


Fig. 12. Contrast of fruiting specimens of: **a)** *Crataegus tenuior* (not collected, Inch Logan Rd, nr. Enderby. BC); **b)** *C. macracantha* var. *occidentalis* showing deep red mature fruiting stage (not collected, Palmer Lake, WA; photo R.J. O'Kennon). Note differences in leaf shape, stiffness and coriacity, delicacy/robustness of twigs, number of fruit in infructescences.

Other macracanthoid western hawthorns with some similarities to *Crataegus tenuior*.—It is worth drawing attention to the following additional western populations with some *Crataegus tenuior* characteristics. In the Mogollon Mts. of New Mexico a small and isolated population of a macracanthoid *Crataegus* with glandular petioles is known. This is represented by *O'Kennon, Huff & Snowden 13427* (TRT, flowering), *Huff et al. 1380* (UNM 86261, fruiting), and *Kirkeminde 897* (UNM 83115, fruiting) and has the further features of pink-purple anthers and yellow autumnal color but clearly pitted nutlets. This population lies well to the south of the southernmost populations of *C. chrysocarpa* in central Colorado but too little is known it about to warrant further comment. Rather similar populations of *C. macracantha* in Arizona have pink-purple anthers and pitted nutlets though typically eglandular petioles—such populations appear scarce west of the Rocky Mountain front, the region dominated by var. *occidentalis* and there is an unconfirmed report by Nadia Talent (pers. comm.) from Gregory Canyon, Colorado. Also, in northwest Montana there is a substantial population of a pink-anthered, glandular-petioled, pitted-nutlet morphotype closely resembling *C. macracantha*.

CRATAEGUS OKANAGANENSIS VAR. *LONGISPINA*

Crataegus okanaganensis (ser. *Purpureofructae*) is a large hawthorn with stout thorns, readily distinguished from *C. douglasii* and immediate allies not only by thorn measurements and fruit color but by the serial characteristic of typically large, pointed, fruiting sepals in contrast to the much smaller, often blunt ones found in ser. *Douglasianae*. The following key distinguishes the *Purpureofructae* of the Okanagan.

1. Leaf blades of a broader form, elliptic to broad-elliptic or suborbiculate or broad-ovate to ovate-elliptic; lobes short, tips obtuse to subacute; fruit oblong or subspherical.
   2. Leaf blades elliptic to broad-elliptic or suborbiculate, lobes acute, strikingly pale green at anthesis; inflorescences only thinly hairy; sepals narrow-triangular; pomes 7–10 mm diam.,± oblong, claret in late August, becoming deep burgundy in September _____ **Crataegus orbicularis**
   2. Leaf blades broad-ovate to ovate-elliptic, lobes subacute to obtuse, mid green at anthesis; inflorescences densely pubescent; sepals broad-triangular; pomes ± 12 mm diam., subglobose, bright or deep red in August, becoming nearly black in September _____ **Crataegus phippsii**
1. Leaf blades narrow-ovate to rhombic-elliptic or elliptic else ovate to rhombovate, lobes ± sharp; fruit ampulliform or rarely subsperical.
   3. Thorns usually ± stout, 2–4 cm; leaf-blades rhombovate, ovate or elliptic-oblong, ± glossy, shiny mid to deep green, ± coriaceous; stamens 5–10, anthers nearly always cream or white; sepals in fruit erectopatent to reflexed, narrow; pomes bright to deeper red late August, becoming dark purple in September.
      4. Leaf blades 3.5–6 cm, coriaceous, without strongly impressed venation adaxially, flattish to strongly concave, usually mid-green until fall _____ **Crataegus okanaganensis**
      4. Leaf blades 4–8 cm, softly coriaceous, with distinctly impressed venation adaxially, flattish to convex, usually deep green until fall _____ **Crataegus enderbyensis**
   3. Thorns usually ± slender, 3–5(–7) cm; leaf-blades elliptic to broad-elliptic or narrow-ovate to rhombovate, matte, deep dull green; not coriaceous; stamens 10 or 20, anthers pink; sepals in fruit suberect, broad, herbaceous; pomes deep burgundy in late August, purple-black in September _____ **Crataegus atrovirens**

Crataegus okanaganensis var. *longispina* (Figs. 15–17) is represented by a series of specimens that in most technical characters resemble the typical, common, variety of the species but differ in their much longer thorns, often much larger leaves, much more densely pubescent, even tomentose, inflorescence branches and hypanthia, 5–6 normally pale pink anthers, and usually more hairy fruit. This ensemble of characteristics is not found in the common varieties of *C. okanaganensis*, a fruiting specimen of which is illustrated in Figure 18 for comparison, and for this reason a new variety is recognized.

Crataegus okanaganensis var. *longispina* is a local taxon found in British Columbia in the southeastern Shuswap region, from Enderby to Salmon Arm.

Crataegus okanaganensis J.B. Phipps & O'Kennon var. **longispina** J.B. Phipps, var. nov. (**Figs. 13–17**). TYPE: CANADA: BRITISH COLUMBIA: sw Shuswap region, N of Enderby, Anderson Rd., bush 7 m tall, fruit plum-red, 5 filament bases, 7 Sep 2001, *JB Phipps & RJ O'Kennon 8281* (HOLOTYPE: TRT; ISOTYPE: UBC).

Frutices, 3–8 m alti; ramuli novelli dense pubescentes, eis unius anni mid- vel atro- nitentes rubro-brunnei; spinae 4–7 cm longae, atro-rubro brunneae vel atrae, ± tenues, rectae vel leviter recurvatae. Folia decidua, petiolata; petioli ca. 25–30% longi quam laminae, ± pubescentes, dense sic in sulcis, eglandulares vel cum sparsis glandis nigris parvis; laminae rhomb-ovatae (vulgo) vel late ellipticae, 4.5–9(–10) cm longae, saepe ± convexae, basibus ± late-cuneatis, (2–)3–4 lobatae per latus, max. IFI ca. 15% (in laminis angustioribus) - 25% (in laminis



Fig. 13. Comparison of fruiting specimens of *Crataegus macracantha* var. *occidentalis*. **a)** stouter form showing typical orange-colored earlier fruiting stage (not collected, Palmer Lake, WA; photo R.J. O'Kennon); **b)** more delicate form (*Phipps 6814*, Shuswap valley, BC). Note differences in leaf shape, stiffness and coriacity, delicacy/robustness of twigs, number of fruit per infructescence.

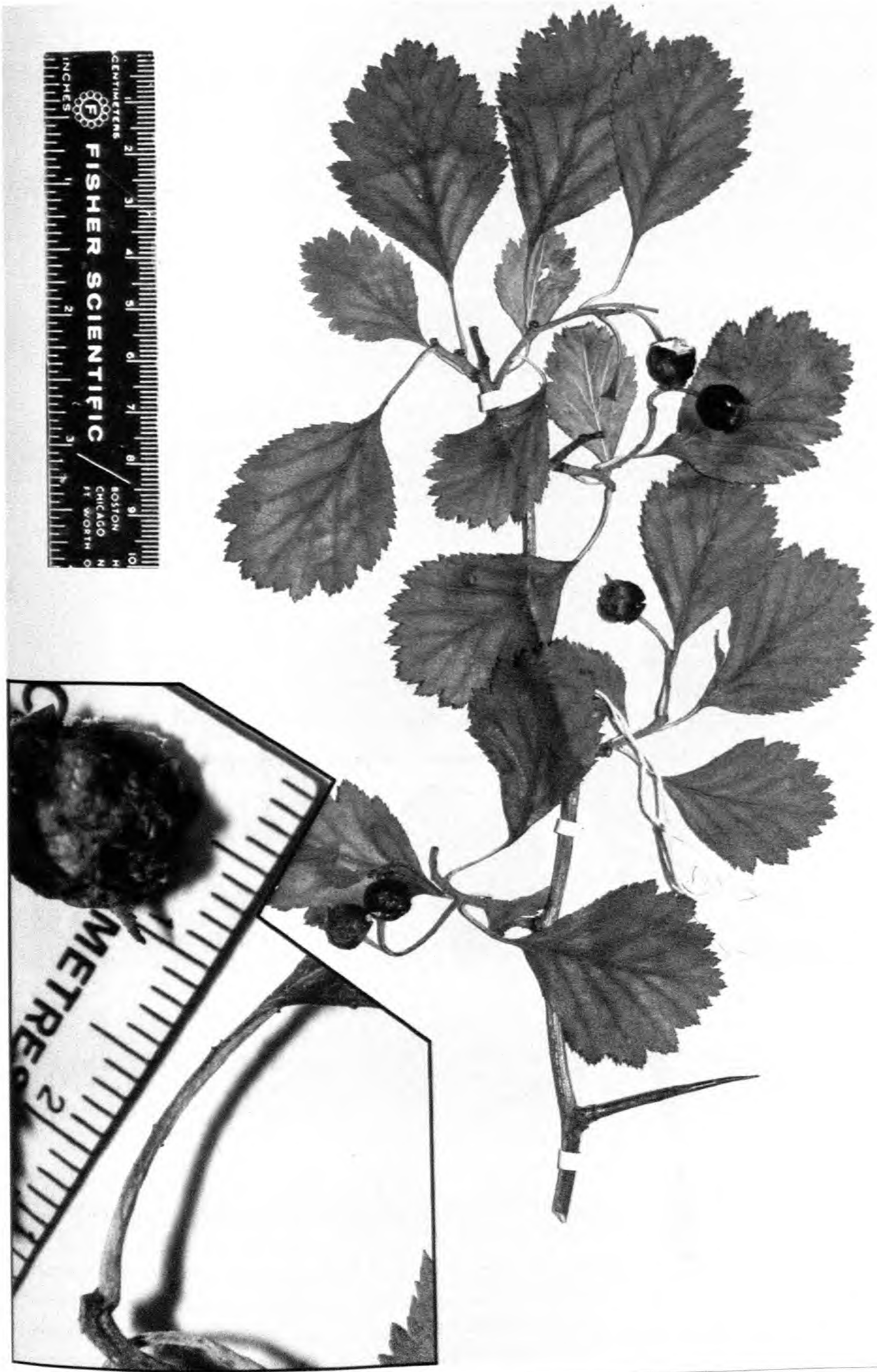


Fig. 14. Fruiting specimen of presumed *Crataegus chrysocarpa* × *C. macracantha* (OTU 22, *Phipps & O'Kennon 7103*). Note leaf shape; magnification shows glands on petiole; ignore fruit on ruler. Tonasket, Washington.



Fig. 15. *Crataegus okanaganensis* var. *longispina* flowering specimen (*Phipps 6962*). Note large leaves, long thorns; pedicel indumentum not resolved.



FIG. 16. *Crataegus okanaganensis* var. *longispina*. Magnification of part of inflorescence (*R.C. Jackson* for *Phipps 8416*). Note dense indumentum of pedicel.

latioribus), lobis acutis, venis 4–9(–10) per latus, marginibus serratis basi excepta, adaxialiter persistente appresso-pubescentes, abaxialiter pubescentes in venis, superficiebus pubescentibis glabrescentibus. Inflorescentiae 5–10 floratae; ramuli dense pubescentes vel subtomentosi; bracteolae caducis breve tempore, lineares, glanduloso-marginatae, glandis sessilis sed breve-stipitatis in maioribus. Flores 12–15 mm diam.; hypanthium dense pubescens vel subtomentosum; sepala 6–7 mm longa, marginibus glandulo-denticulatis; petala late-obovata, breve-clavata; stamina 5–8, antheris albis vel pallide roseis; styli 3. Fructus urceolato-ellipsoidei, 13 mm longi, villosi, Augusti exeunte rubri, Septembri exeunte atrovinacei; reliquiae sepalorum longae, erecto-patentes vel recurvatae, marginibus glandulo-serratis; pyrenae 3, dorsale sulcatae, lateribus planis vel leviter asperibus.

Bushes, 3–8 m tall; extending twigs densely pubescent, at 1-yr. old mid- to darker, shiny reddish-brown; thorns 4–7 cm long, very dark red-brown to black, ± slender, straight to slightly recurved. Foliage deciduous, petiolate; petioles ca. 25–30% as long as blades, ± pubescent, densely so in sulci, eglandular or with sparse small black glands; blades rhomb-ovate (mainly) to broad-elliptic, 4.5–9(–10) cm long, often ± convex, bases ± broad-cuneate, (2–)3–4 lobed per side, max. LII ca. 15% (narrower leaves) –25% (broader leaves), lobes acute, 4–5 veined per side, margins serrate except near the base; adaxially persistently appressed-pubescent, abaxially surfaces scattered pubescent, glabrescent, veins pubescent. Inflorescences 5–10 flowered, branches densely pubescent to almost tomentose, bracteoles early caducous, linear, gland-margined, glands sessile except short-stipitate in larger bracteoles. Flowers 12–15 mm diam.; hypanthium densely pubescent to almost tomentose, sepals 6–7 mm long, margins glandular-denticulate; petals broad-obovate, short-clawed; stamens 5–8, anthers ivory to pale pink; styles 3. Fruit flask-shaped to ellipsoid, 13 mm long, villous, red in late August,

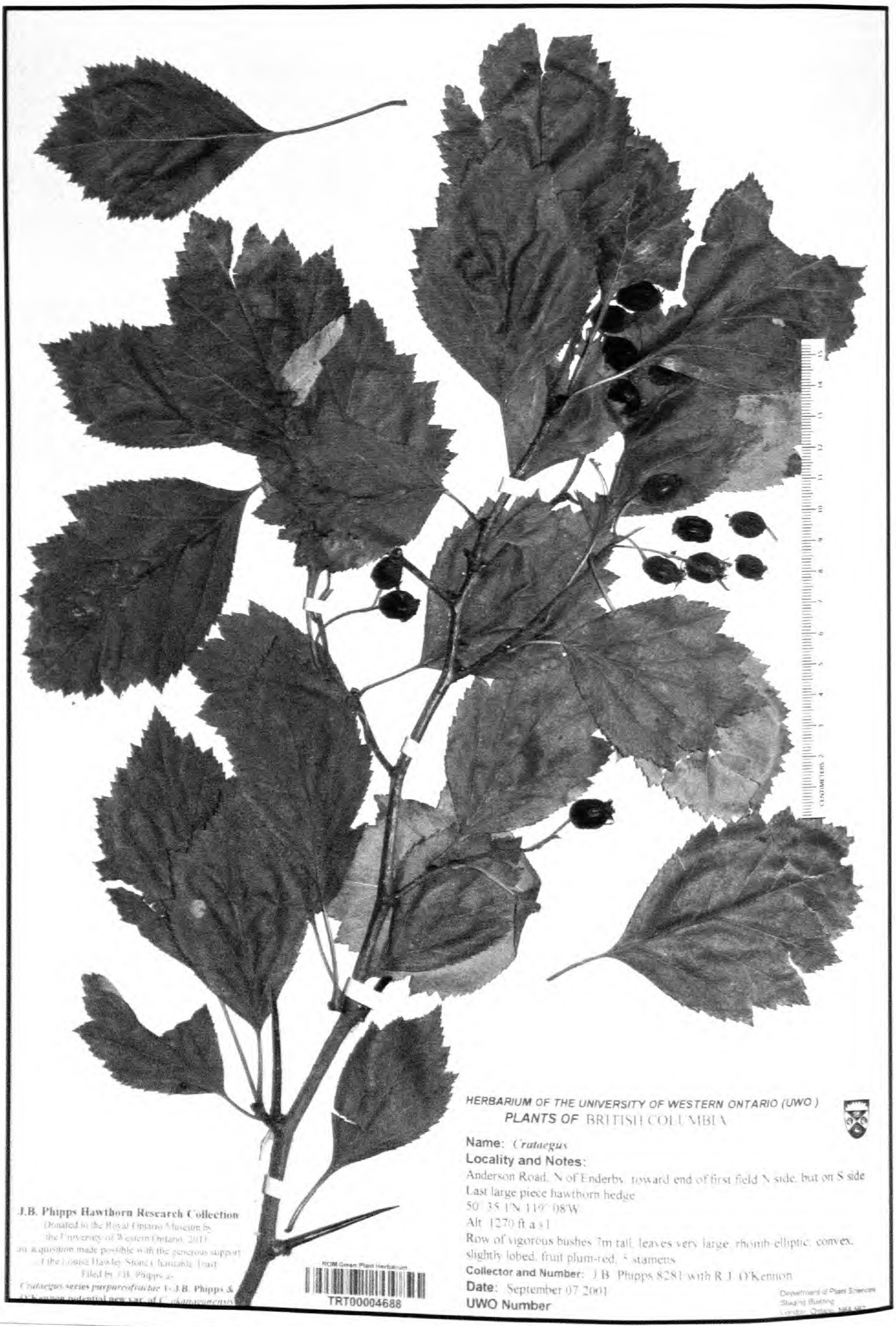


FIG. 17. *Crataegus okanaganensis* var. *longispina* fruiting specimen (*Phipps & O'Kennon 8281*). Note very large leaves; the two 4 cm thorns seen are short for this variety.

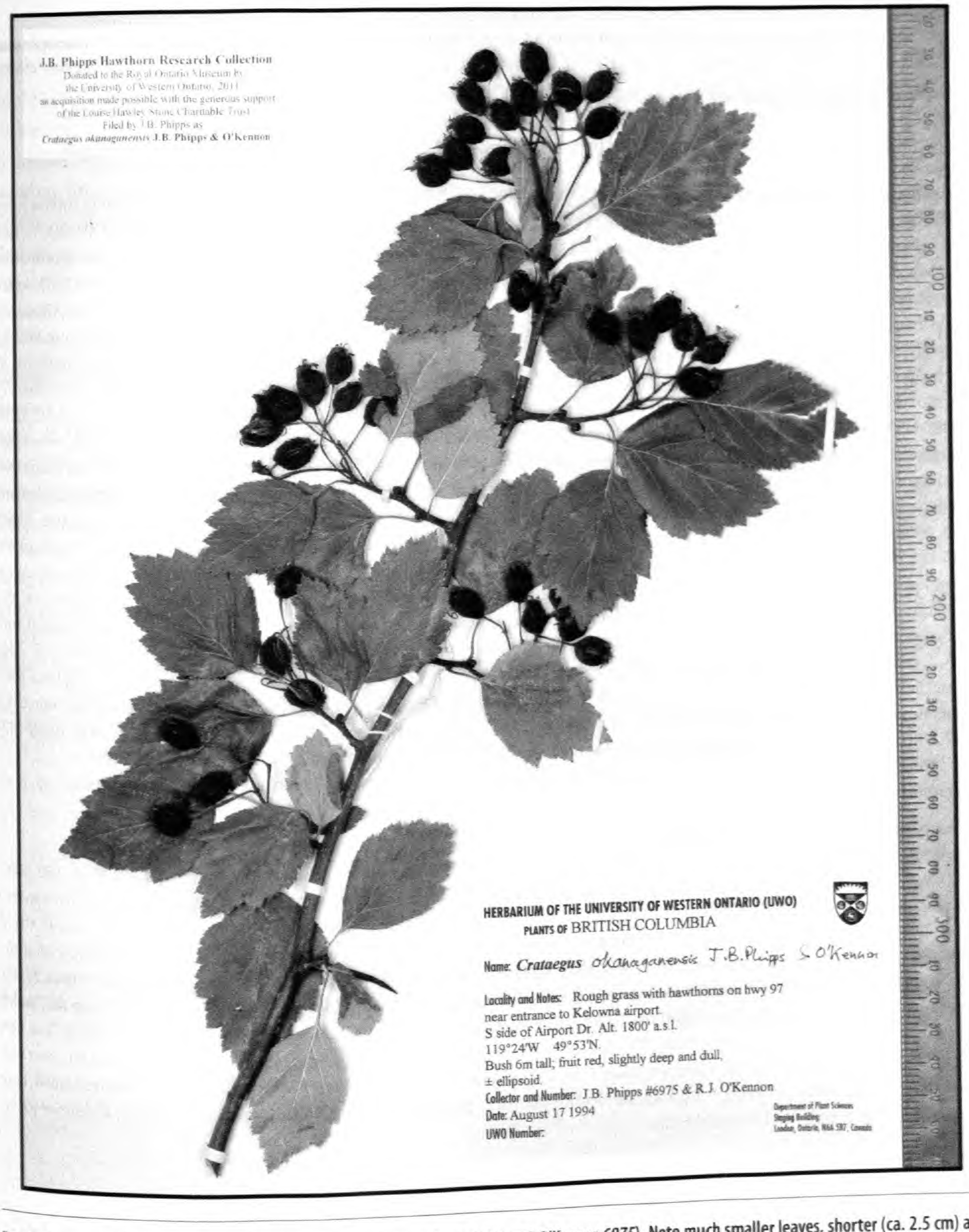


Fig. 18. *Crataegus okanaganensis* var. *okanaganensis* fruiting specimen (*Phipps & O'Kennon 6975*). Note much smaller leaves, shorter (ca. 2.5 cm) and proportionately stouter thorns, very sparse pedicel indumentum.

burgundy in late September, with long erecto-patent sepals or their remnants, margins glandular-serrate; nutlets 3, dorsally grooved, sides smooth to a little rough.

The key distinguishes the new variety from the other, much commoner, varieties of *Crataegus okanaganensis*.

1. Thorns ± slender, 4–7 cm long; extending shoots, inflorescence branches, and hypanthia densely pubescent; anthers 5–8, usually tinged with pink particularly when young (less commonly white*); leaf blades 4.5–9 cm long; fruit ca. 13 mm high _____ **C. okanaganensis** var. **longispina**

1. Thorns ± stout, 2–3(–4) cm long; extending shoots, inflorescence branches, and hypanthia glabrous or ± thinly pubescent; anthers ca. 10, ivory or very rarely pink; leaf blades 3.5–6 cm long; fruit ca. 9–12 mm high _____ **C. okanaganensis**
other varieties

*The white-anthered variant was seen at Salmon Arm.

Additional Cited Specimens [collectors abbreviated from following names: J.B. Phipps, R.J. O'Kennon, and R. Jackson (for JBP)]:

1. Crataegus tenuior

Flowering: BRITISH COLUMBIA: northern Okanagan, Spallumcheen Mun.: Back Enderby Road, delicate bush, 7m, young anthers strong salmon-pink, 18 May 2002, *JBP 8370* (TRT, UBC); Back Enderby Road, small bush, 5 pink anthers, 23 May 2002, *RJ/JBP 8400* (TRT, V); Back Enderby Road, small tree, 6 medium-pink anthers, 23 May 2002, *RJ/JBP 8401* (DAO, TRT); north central Shuswap region: 2 km E of Enderby, bush 3 m, 10 pink anthers, *JBP 6918*, 5 May 1994 (TRT); 8 km E of Enderby, bush 4 m, 10 pink anthers, *JBP 6923*, 5 May 1994 (TRT); Anderson Rd., bush 5 m, 6–8 light pink anthers, *RJ/JBP 8389*, 22 May 2002 (TRT, UBC). **Fruiting: BRITISH COLUMBIA:** northern Okanagan, Spallumcheen Mun.: Back Enderby Road, W side, S of mailbox 5135, natural hedgerows, fruit orange-yellow to bright red, 25 Aug 2002, *RJ/JBP 8451*, 25.viii.2002 (TRT, WTU); Back Enderby Road, W side, S of mailbox 5135, natural hedgerows, fruit orange-yellow to bright red, 25 Aug 2002, *RJ/JBP 8452* (TRT, UBC); Back Enderby Road, W side, S of mailbox 5135, natural hedgerows, fruit orange-yellow to bright red, 25 Aug 2002, *RJ/JBP 8453* (TRT, V); Back Enderby Road, W side, S of mailbox 5135, natural hedgerows, fruit yellow-orange, 25 Aug 2002, *RJ/JBP 8454* (DAO, TRT); Back Enderby Road, just N of Stepney Cross road, W side, S of mailbox 5135, natural hedgerows, fruit bright red-orange, 22 Sep 2002, *RJ/JBP 8470* (TRT, UBC, V); Back Enderby Road, just N of Stepney Cross road, W side, S of mailbox 5135, natural hedgerows, fruit bright red-orange, *RJ/JBP 8471* (DAO, TRT, UBC), Back Enderby Road, just N of Stepney Cross road, W side, S of mailbox 5135, natural hedgerows, fruit bright red-orange, *RJ/JBP 8472* (TRT, V); north central Shuswap region: 2 km E of Enderby, bush 3 m, fruit scarlet, 25 Sep 1993, *JBP & O'K 6811* (DAO, TRT, UBC, V); 5 mi E of Enderby, bush 3 m, fruit scarlet, 25 Sep 1993, *JBP & O'K 6814* (TRT); 5 mi E of Enderby, bush 3 m, fruit scarlet, 25 Sep 1993, *JBP & O'K 6814a* (CAN, DAO, TRT, UBC, V, WTU); Ca. 200 m E of Shuswap River bridge on Enderby-Mabel Lake Road, S side, top of river bank among scrub, slender bush, 4 m tall, fruit light salmon, type bush, 20 Aug 1994, *JBP & O'K 7011* (TRT, UBC, WTU); ca. 200 m E of Shuswap River bridge on Enderby-Mabel Lake Road, S side, edge of swampy woods, bush, 3 m tall, fruit light salmon, 20 Aug 1994, *JBP 7013 & O'K* (DAO, TRT); Valley of the Shuswap, ca. 8 km E of Enderby, a little to the E of Brash Creek, S side of road, woodland edge, bush 4 m tall, fruit salmon-orange, 20 Aug 1995, *JBP 7171* (TRT, V), Anderson Road, S side, at 1.5 telephone posts beyond farm surrounded by lots of pines, bush 3m tall, fruit reddish-orange, 7 Sep 2001, *JBP & O'K 8274* (TRT); Anderson Road, S side, at 1.5 telephone posts beyond farm surrounded by lots of pines, bush 6 m tall, fruit orange-red, 7 Sep 2001, *JBP & O'K 8275* (TRT); *RJ/JBP 8474* (TRT, UBC). **WASHINGTON: Okanogan Co.:** near Palmer Lake, bush 3 m, fruit scarlet, 4 Sep 2001, *JBP & O'K 8265* (TRT).

Note that duplicate specimens of *C. tenuior* distributed prior to this paper were probably identified as *Crataegus* sp. or *C. macracantha*.

2. Crataegus okanaganensis var. **longispina**

Flowering: BRITISH COLUMBIA: Salmon Arm, dump site, bush 2.5 m, 5–6 white anthers, 10 May 1994, *JBP 6962* (CAN, DAO, TRT, UBC, UVIC, V, WTU); north central Shuswap region: Enderby-Grindrod Rd., between Anderson Rd. and Inch Logan Rd., sapling, 5 ivory to very pale pink anthers, 22 May 2002, *RJ/JBP 8392* (TRT, UBC); Enderby-Grindrod Rd., betw. Anderson Rd. and Inch Logan Rd., (small) tree, 5 ivory to very pale pink anthers, 22 May 2002, *RJ/JBP 8393* (CAN, TRT, V); Enderby-Grindrod Rd., betw. Anderson Rd. and Inch Logan Rd., mature tree, 5 ivory to very pale pink anthers, 22 May 2002, *RJ/JBP 8394* (TRT, UBC); Anderson Rd., bush 8 m, 5 light pink anthers, 31 May 2002, *RJ/JBP 8415* (TRT, UBC); Anderson Rd., bush 8 m, 5 light pink anthers, 31 May 2002, *RJ/JBP 8416* (DAO, TRT); Anderson Rd., bush 8 m, anthers old, darkened, 31 May 2002, *RJ/JBP 8417* (TRT, UBC). **Fruiting:** BRITISH COLUMBIA: Salmon Arm, dump site, bush 2.75 m, fruit red, 20 Jul 1994, *JBP & O'K 7026* (CAN, DAO, TRT, UBC, UVIC, V, WTU); north central Shuswap region: Enderby-Grindrod Rd., near Inch Logan Rd., 3 m bush, burgundy fruit, 5 filament bases, 7 Sep 2001, *JBP & O'K 8273* (TRT); Hwy. 97A, N of Enderby, nr. Jim's fruit stand, bush 3 m, fruit plum-red, 5 filament bases, 7 Sep 2001, *JBP & O'K 8282* (TRT). Spallumcheen Mun.: W side Rd., NW of Vernon, 3.5 km S of jct. 97, 25 Aug 2002, *RJ/JBP 8463* (TRT) is possibly this.

CONCLUSIONS

Although earlier treatments of the *Crataegus* flora of British Columbia and adjacent Washington (e.g., Hitchcock & Cronquist 1973; Taylor 1973; Brayshaw 1996) reported few species for the area, intensive collecting between 1993 and 2002 in the greater Okanagan has yielded a further eight species and several varieties of this genus (Phipps & O'Kennon 1998, 2002, 2004). Thus, far from a position that the northern Okanagan-southeastern Shuswap is of no special evolutionary interest, perhaps true for many groups of plants, it is clear that the area is a Nirvana for hawthorns: it is mesic, it has sufficient open habitat and the temperature band is favorable.

This paper supersedes the relevant parts of the author's treatment for *Crataegus* in Flora of North America, volume 9.

ACKNOWLEDGMENTS

I wish to thank Bob O'Kennon of BRIT for many happy and fruitful hours of companionship in the field during the discovery process for these new taxa and for several photographs as indicated on their captions. Antony Littlewood, Dept. of Classical Studies, The University of Western Ontario, is thanked for checking the Latin diagnoses. Nadia Talent, University of Toronto, and Tim Dickinson, University of Toronto and Royal Ontario Museum, are thanked for comments on an earlier version of the manuscript. Alan Noon, Dept. of Biology, The University of Western Ontario, is thanked for photography of herbarium specimens and Ian Craig, Imaging Unit, Dept. of Biology, The University of Western Ontario, for his assistance in preparing the figures for the paper. Financial assistance for publication was provided by Barney Lipscomb and Bob O'Kennon.

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BOOK REVIEW

GEOFF WILLIAMS AND PAUL ADAM. 2010. **The Flowering of Australia's Rainforests: A Plant and Pollination Miscellany.** (ISBN: 9780643097612, hbk). CSIRO PUBLISHING, P.O. Box 1139, Collingwood, Victoria 3066, AUSTRALIA. (**Orders:** www.publish.csiro.au (Australia), www.styluspub.com (U.S.A. & Canada), www.eurospanbookstore.com (U.K., Europe, Middle East, & North Africa)). AU $99.95, US $93.00, 216 pp., 8" × 10 ½".

A word of caution before continuing: this is obviously a beautiful book, with attractive cover, excellent photographs, and appealing content and information. Be very alert to the second sentence in the Preface: "But readers will find that from time to time we have taken a *circuitous path that too easily voyages to the shores of other lands*, that finds interest in plants that do not belong solely or even tenuously to the rainforest environment, *that we are inclined to revisit matters that are worth retelling from different perspectives, and that small portions of related knowledge are given an airing in diverse quarters.*" (Italics mine.)

If you are planning to use the excellent and diverse information given, be sure to keep a notebook and pen or pencil close at hand. Note page numbers and subject content for key information. You will find related comments and data scattered throughout the volume. It will save you much time and frustration if you have recorded locations of previous discussions of the same or related topics and can find them easily. Comparisons are not only helpful but occasionally unexpected.

After the explanatory Introduction, the first chapter, "Flowers and pollination in lore and legend" was a bit unexpected but very informative. A nice addition, to be sure. The second chapter, "Categorising rainforest plants," is self-explanatory. Immediately following are 34 color photographs, beautifully providing an overview of plants and habitations.

Chapters 3 through 9 are quite diverse in subject content. They cover a variety of helpful (and sometimes unexpected) topics. For example, Chapter 4 is entitled "Being a flower"—a relatively lengthy chapter; Chapter 5, "Introduction to breeding systems;" Chapter 6, "Spatial and temporal structure of rainforest: general mechanisms that influence pollination and reproductive ecology;" Chapter 7, "Australian vegetation history and its influence on plant-pollinator relationships;" Chapter 8, "Pollination and the Australian flora;" and Chapter 9, "Pollination syndromes: who brings the 'flower children' in rainforest?" The titles definitely catch one's attention, and each chapter obviously has been carefully researched, evaluated, and presented in specific detail.

Eight appendices and the bibliography complete the volume. Appendix 1, "Pollination ecology of Australian subtropical rainforests: implications for the conservation of remnant communities," echoes and confirms a definite concern for the fragmented parts of the Australian rainforests. Before the European settlements the Australian rainforest covered about 8 million hectares; now only about 2 million hectares exist, mostly along the eastern coast, with 54% in Queensland. Furthermore, on the eastern coastal fringe, existing communities are in "disjunct remnants threatened by invasion of exotic weeds and animals and by human impacts."

Obviously, this is a matter of growing and great concern, not only for Australia but of nearly worldwide awareness.—*Helen Jeude, Volunteer & Assistant Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

IDENTIFICATION, DISTRIBUTION, AND HABITAT OF *COREOPSIS* SECTION *EUBLEPHARIS* (ASTERACEAE) AND DESCRIPTION OF A NEW SPECIES

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ABSTRACT

Species of *Coreopsis* occurring on the North American coastal plain continue to present identification challenges. Here we provide a revised key, identification notes, habitats, and range maps for nine species. **Coreopsis aristulata** LeBlond, Sorrie & Weakley is newly described here.

RESUMEN

Las especies de *Coreopsis* de la llanura costera Norte Americana continúan presentando problemas de identificación. Aportamos aquí una clave revisada, notas de identificación, hábitats, y mapas de distribución de nueve especies. Se describe como nueva **Coreopsis aristulata** LeBlond, Sorrie & Weakley.

INTRODUCTION

Coreopsis is a genus of 35 species, 28 in North America and seven in the neotropics and paleotropics (Strother 2006). Section *Eublepharis* Nutt. is strictly eastern North American, ranging on the coastal plain from southern Nova Scotia to southern Florida and eastern Texas. There has been limited agreement on the number of species that previous authors recognized (Table 1), with disagreement centering on *C. gladiata*, *C. linifolia*, *C. helianthoides*, and *C. floridana*. In our view, the recent treatments by Cronquist (1980) and Strother (2006) recognize too few species, compared with the number that we routinely identify during field and herbarium work throughout the southeastern coastal plain. We base our conclusions on the consistency within each species regarding plant morphology (several characters), habitat fidelity, and coherent geographical distribution. Our conclusions, presented below, are largely supported by molecular work using sequences from nuclear ITS and plastid regions (Crawford & Mark 2005), who report a well-resolved phylogeny of the genus in eastern North America, including monophyly of section *Eublepharis*. The authors sampled five species within this section: *C. floridana*, *C. gladiata*, *C. integrifolia*, *C. linifolia*, and *C. rosea*. However, Crawford and Mark stated that "additional field and labratory studies are needed to elucidate relationships in this species complex." In this paper we provide rationale for recognizing nine species in section *Eublepharis*: *C. falcata* F.E. Boynton, *C. floridana* E.B. Smith, *C. gladiata* Walter, *C. integrifolia* Poiret, *C. linifolia* Nutt., *C. nudata* Nutt., *C. palustris* Sorrie (= *C. helianthoides* Beadle misapplied), *C. rosea* Nutt., and *C. aristulata* LeBlond, Sorrie & Weakley (newly described below). *Coreopsis longifolia* Small and several other taxa not recognized here are synonymized in the treatment which follows.

METHODS

The current study was conducted primarily by the first author over a period of twenty years while gathering specimen information on endemic species of the North American coastal plain. Specimens annotated by E.B. Smith served as a baseline, augmented by newly constructed keys and annotations of specimens accessioned since Smith's work. Smith (1976) provided illustrations, including achenes, for seven species; Godfrey and Wooten (1981) illustrated six species. These drawings were critical to forming working concepts of "typical" examples of the species; herbarium specimens provided data on variation within each species. Measurements were made of 20–25 mature achenes (1–2 per specimen) from specimens at NCU. Smith (1976, 1978) cited

TABLE 1. Species of *Coreopsis* section *Eublepharis* recognized by various authors. * = described in 1976. # = not known from flora area at the time, but subsequently documented.

	Small 1933	Sherff 1936	Radford et al. 1968	Smith 1976	Cronquist 1980	Strother 2006	Sorrie et al. this paper
aristulata	–	–	–	–	–	–	x
falcata	x	x	x	x	–	–	x
*floridana**	–	–	–	x	–	–	x
gladiata	x	x	x	x	x	x	x
integrifolia	x	x	– #	x	x	x	x
linifolia	x	x	x	x	x as var. of gladiata	–	x
longifolia	x	x	–	–	–	–	–
nudata	x	x	–	x	x	x	x
palustris (*helianthoides*)	x	x	x	–	x	–	x
rosea	x	x	– #	x	x	x	x

types, which we have seen in hand or online. Specimens were examined at DUKE, FLAS, FSU, GA, GH, MO, NCSC, NCU, NY (types online), US (types online), and USCH. Maps were produced using a program created by Mike Lee of University of North Carolina, Chapel Hill.

RESULTS AND DISCUSSION

Achene morphology

Achenes of *Coreopsis* section *Eublepharis* are notable for their pectinate wings, absent only in *C. rosea*. The achene body has numerous processes on the lateral margins that form the wings; these processes may be narrow and sharply pointed, but in most species are broader and truncate-tipped or notched. The achene body is surmounted by a pappus composed of two sharply pointed awns. Smith (1976) and Godfrey & Wooten (1981) provide excellent illustrations of achenes of most species. Achene morphology can provide important secondary identification characters, in addition to those in the key below. For example, *C. rosea* achenes lack wings and awns, *C. linifolia* wings have sharply pointed processes, *C. integrifolia* has markedly long achenes and very short awns, and *C. falcata* has markedly broad wings. Table 2 gives mensural data for several achene characters.

KEY TO THE SPECIES

1. All major cauline leaves opposite (excluding basal and lowermost leaves of *C. integrifolia* and *C. linifolia*).
   2. Ray ligules pink to rosy (rarely white); leaf blades linear, the lowermost oblanceolate — **C. rosea**
   2. Ray ligules yellow; leaf blades linear-oblanceolate to linear, or ovate.
      3. Blades ovate (to elliptical), very gradually reduced upward, margins ciliolate, surfaces lacking minute dark dots; achenes average about 5 mm long — **C. integrifolia**
      3. Blades linear-oblanceolate to linear, rapidly reduced upward, margins glabrous, surfaces with numerous minute dark dots (easiest to see on abaxial surface); achenes average less than 2.5 mm long — **C. linifolia**, in part
1. All major cauline leaves alternate (only one or a few lower leaves alternate in *C. linifolia*).
   4. Leaves junciform (linear-terete); ray ligules pink to deep rosy (rarely white) — **C. nudata**
   4. Leaves not junciform, with expanded blades, blades linear-oblanceolate to linear or broader; ray ligules yellow.
      5. Outer phyllaries deltoid and short, less than 0.3x length of inner phyllaries; flowering late Sep–Feb; endemic to Florida — **C. floridana**
      5. Outer phyllaries lanceolate, 0.4–0.8x length of inner phyllaries; flowering May–early Nov; distribution various.
         6. Basal and lower leaves (at least 4 nodes) absent at anthesis; plants of swamp forests, streamside openings, and fresh-tidal creek margins OR of calcium-influenced acidic savannas.
            7. Mid-cauline leaves broadly (to narrowly) elliptical; achene awns average 0.8 mm; plants of swamp forests and streamside openings, fresh-tidal creek margins, rarely in calcium- influenced acidic savannas; ranges from se NC-ne FL — **C. palustris**
            7. Mid-cauline leaves narrowly linear to linear-oblanceolate; achene awns average 0.3 mm; plants of calcium-influenced acidic savannas; restricted to se NC — **C. aristulata**
         6. Basal and lower leaves present at anthesis; leaves rapidly reduced upwards such that mid-cauline leaves are slender; plants of wet savannas, seepage slopes, pitcher-plant bogs, streamhead ecotones, pocosin ecotones.
            8. Lower cauline leaves with numerous minute dark dots (easiest to see on abaxial surface); heads (including

TABLE 2. Achene characters of *Coreopsis* section *Eublepharis*, based on 20–25 measurements, in millimeters. Only mature achenes were sampled.

	achene body length	achene body width	wing width	awn length
aristulata	3.3–3.4 $\bar{x}$ =3.4	0.8–1.1 $\bar{x}$ =1.0	0.2–0.2 $\bar{x}$ =0.2	0.2–0.3 $\bar{x}$ =0.3
falcata	2.9–4.0 $\bar{x}$ =3.3	0.9–1.1 $\bar{x}$ =1.0	1.0–1.1 $\bar{x}$ =1.0	0.3–0.7 $\bar{x}$ =0.5
floridana	3.7–4.3 $\bar{x}$ =4.0	1.1–1.3 $\bar{x}$ =1.2	0.3–0.5 $\bar{x}$ =0.4	0.8–1.2 $\bar{x}$ =1.0
gladiata	2.8–4.2 $\bar{x}$ =3.6	0.9–1.6 $\bar{x}$ =1.2	0.1–0.4 $\bar{x}$ =0.3	1.0–2.0 $\bar{x}$ =1.5
integrifolia	4.3–5.5 $\bar{x}$ =5.0	0.9–1.3 $\bar{x}$ =1.1	0.3–0.4 $\bar{x}$ =0.3	0.5–1.0 $\bar{x}$ =0.7
linifolia	2.0–3.0 $\bar{x}$ =2.4	0.9–1.0 $\bar{x}$ =1.0	0.3–0.4 $\bar{x}$ =0.4	1.0–1.9 $\bar{x}$ =1.4
nudata	2.6–3.7 $\bar{x}$ =3.0	0.9–1.2 $\bar{x}$ =1.0	0.4–0.6 $\bar{x}$ =0.5	1.0–1.5 $\bar{x}$ =1.2
palustris (*helianthoides*)	2.8–3.8 $\bar{x}$ =3.5	1.0–1.8 $\bar{x}$ =1.3	0.4–0.6 $\bar{x}$ =0.5	0.6–1.0 $\bar{x}$ =0.8
rosea	1.7–3.5 $\bar{x}$ =2.0	0.6–0.9 $\bar{x}$ =0.7	absent	absent

extended rays) 2.5–4.0 cm diameter; median and upper leaves opposite, one to few lower leaves alternate; achene awns average 1.4 mm ____ **C. linifolia** in part

8. Lower cauline leaves without dark dots; heads 3.5–6.0 cm diameter; all major leaves alternate; achene awns average 1.5 mm or 0.5 mm.
   9. At least one major leaf per plant with one or more slender lobes near base; achene wing broad, ≥¾ width of achene body; achene awns average 0.5 mm; plants blooming early May–early Jul ____ **C. falcata** in part
   9. Leaves without basal lobes; achene wing variable; achene awn length variable; blooming period variable.
      10. Achene wing broad, ≥¾ width of achene body; achene awns average 0.5 mm; leaf texture firm but not thick and leathery; plants blooming early May–early Jul ____ **C. falcata** in part
      10. Achene wing narrow, <½ width of achene body; achene awns average 1.5 mm; leaf texture thick and leathery; plants blooming early Sep–early Nov ____ **C. gladiata**

Specimens of an unfamiliar *Coreopsis* were found by Richard LeBlond in southeastern North Carolina in 1996. It is describe as follows:

1. Coreopsis aristulata LeBlond, Sorrie & Weakley, sp. nov. (**Figs. 1, 2**). TYPE: U.S.A. NORTH CAROLINA. Onslow Co.: Sandy Run Swamp Powerline Savanna natural area, with *Myrica cerifera, Helianthus angustifolius, Lespedeza cuneata, Eragrostis elliottii, Panicum virgatum* var. *virgatum*, 4 Oct 1996, *LeBlond 4654* (HOLOTYPE: NCU).

Differs from C. palustris in the following combination of characters: Early-deciduous lower leaves of *aristulata* plants resemble *C. palustris* Sorrie (= *C. helianthoides* Beadle misapplied), but differ markedly in the extremely narrow leaves, very short achene awns, and in habitat.

Plants rhizomatous; rhizomes to 14+ cm, 2 mm wide, these and the roots yellow to ochre. Caudex either fastigiated with roots or hardly distinguishable from lower stem. Stems glabrous, 80–110 cm long, 2–3 mm wide at base, 10–13 nodes below inflorescence. Cauline leaves gradually reduced upwards, stem base and lowest 4–6 nodes leafless at anthesis. Petioles 2.0–3.5 cm long, leaf tissue decurrent all of petiole length, bases sheathing stems, sheaths 1–2 mm long. Blades glabrous, linear to linear-oblanceolate, 8–15+ cm long by 2–9 mm wide, 20–50 × as long as wide, thick, stiff, brittle when dry, surfaces smoothish (not scabrous or hairy), margins minutely scabrid. Inflorescence 15–50 cm long, open, corymbose, heads ca. 3.5–4.5 cm wide between tips of opposite rays. Outer phyllaries narrowly lance-oblong, blunt, 3–4 mm long by 0.8–1 mm wide at midpoint, 0.4–0.6 as long as the inner; inner phyllaries ovate-oblong, tapered to blunt tips, 6–7.5 mm long, 3–4.2 mm wide at widest point. Achene bodies oblanceolate-oblong, (3.0–)3.2–3.8 mm long, (0.8–)1.0–1.1 mm wide (not including wings); awns 0.2–0.4 mm long; wings 0.1–0.3 mm wide, pectinate-lacerate.

PARATYPES: **U.S.A. North Carolina. Onslow Co.:** Haws Run Mitigation Site natural area, between Sandy Run Swamp and Shelter Swamp Creek. With *Allium* sp. nov. aff. *cernuum, Thalictrum cooleyi, Fuirena breviseta, Andropogon glaucopsis, Fimbristylis autumnalis, Anthenantia rufa*, 19 Sep 1996, *LeBlond 4600* (NCU); Haws Run Mitigation Site natural area, between Sandy Run Swamp and Shelter Swamp Creek, 3 Oct 2000, *LeBlond 5424 A, -B, -C, -D* (NCU). **Pender Co.:** Shaken Creek Preserve, shallow depression in wet savanna, with *Thalictrum cooleyi, Muhlenbergia expansa, Panicum virgatum var. virgatum*, 23 Oct 2011, *R. Thornhill s.n.* (NCSC, NCU).

Distinguishing Characters.—*Coreopsis palustris* and *C. aristulata* are the only species in section *Eublepharis* with lower leaves deciduous at anthesis. Typically, 4–6 nodes lack leaves or have one or two shriveled senescent leaves. This is a striking character and immediately separates these two species from congeners in the field and in herbaria. The two species can be distinguished by the characters in Table 3.



Fig. 1. Habit of *Coreopsis aristulata*.

Note that leaf width and achene awn length do not overlap between the two species; in fact, awn length of *C. aristulata* is only 38% of that of *C. palustris*. The narrow leaves of *C. aristulata* are similar to those of the narrow-leaved extreme of *C. gladiata* (described as *C. longifolia* Small), and specimens of the latter may be mistaken for the former. However, leaf blades of *C. aristulata* are even longer and more nearly linear than those of "*C. longifolia*", the lowest 4–6 leaves are absent at anthesis (vs. present), and the achene awns are strikingly short (mean 0.3 mm vs. 1.5 mm).

Habitat and Flowering Dates.—*Coreopsis aristulata* occurs in the Very Wet Loamy Pine Savanna natural community type (Schafale 2012), equivalent to the *Pinus palustris—Pinus serotina/Magnolia virginiana/Sporobolus teretifolius—Carex striata* Woodland (CEGL004500) (NatureServe 2012). Community structure in unaltered habitats is characterized by an open to sparse canopy dominated by *Pinus serotina* Michx., and usually with some *P. palustris* P. Mill. and *Taxodium ascendens* Brongn. The shrub layer typically is sparse to patchy,

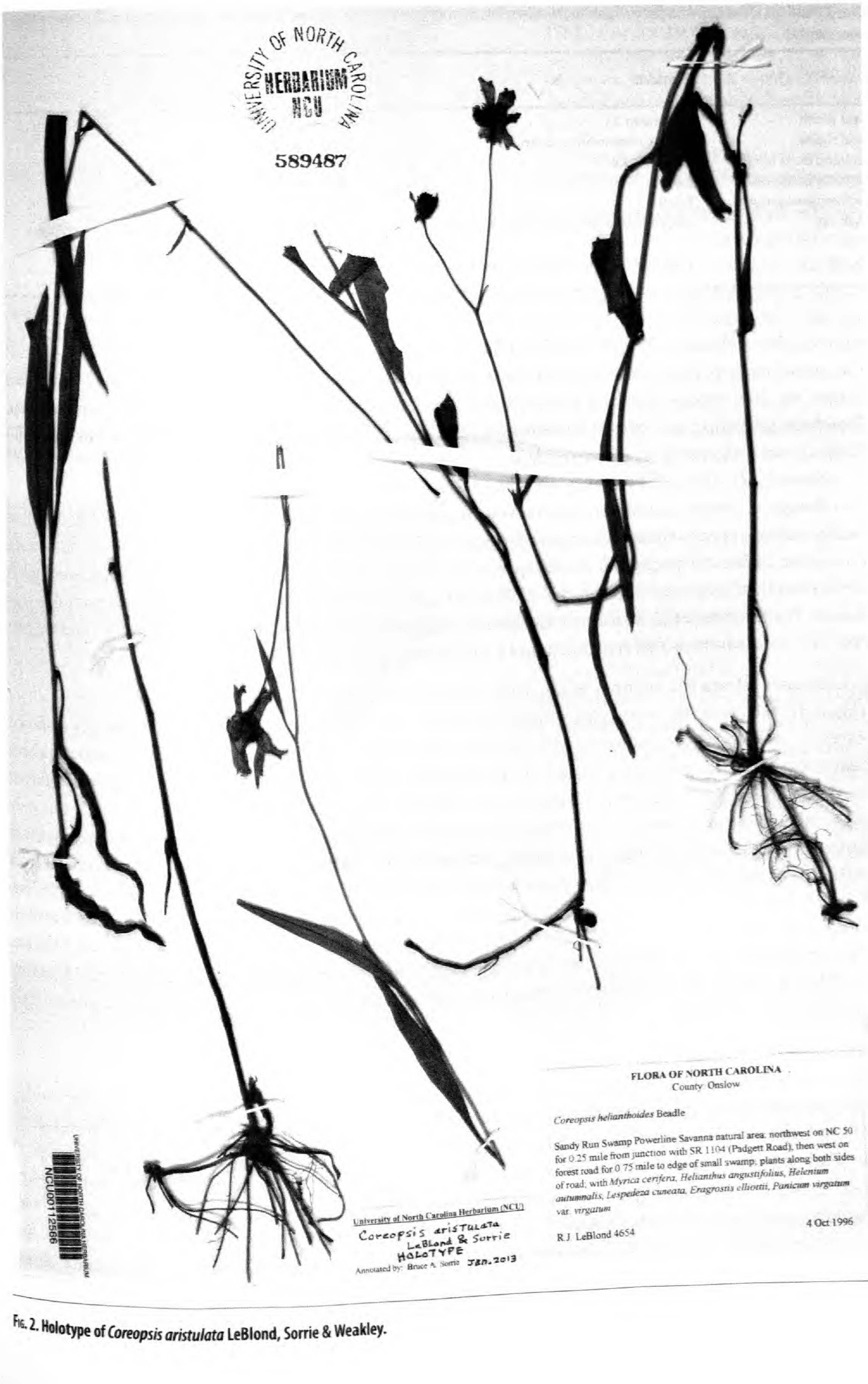


Fig. 2. Holotype of *Coreopsis aristulata* LeBlond, Sorrie & Weakley.

TABLE 3. Characters of *Coreopsis aristulata* vs. *C. palustris*. Measurements are in millimeters. Achene measurements do not include the wings. Only mature achenes were sampled.

	C. aristulata	*C. palustris*
leaf width	2–9; mean 5.1	13–39; mean 22.5
leaf shape	linear to linear-oblanceolate	narrowly elliptic to ovate
achene body length	(3.0–)3.2–3.8	3.0–4.1
achene body width	0.8–1.1	1.0–1.6
achene awn length	0.2–0.4	0.7–1.0
habitat	calcium-influenced wet acidic savannas	wet margins of creeks and rivers; one population in calcium-influenced wet acidic savanna
range	Onslow and Pender counties, North Carolina	se North Carolina to ne Florida

with *Morella caroliniensis* (P. Mill.) Small, *Cyrilla racemiflora* L., *Ilex glabra* (L.) A. Gray, *I. myrtifolia* Walt., and *Vaccinium fuscatum* Aiton prominent. Juvenile *Acer rubrum* L. var. *trilobum* Torrey & A. Gray and *Nyssa biflora* Walter are often present. The herb layer is dense, and dominated by combinations of *Ctenium aromaticum*, *Sporobolus pinetorum*, and several *Rhynchospora* taxa [e.g., *R. pinetorum* Small, *R. latifolia* (Baldwin ex Ell.) Thomas, and *R. thornei* Kral]. Flowering dates: mid Sep–mid Oct.

Etymology.—The specific epithet, *aristulata*, means "with short awn" or "with short bristle."

Range.—*Coreopsis aristulata* occurs only in Onslow and Pender counties, North Carolina (Fig. 3). Other locally endemic species share this range and specialized habitat: *Allium* sp. nov. aff. *cernuum* Roth (Alliaceae), *Carex lutea* LeBlond (Cyperaceae), *Scleria* sp. nov. aff. *elliottii* Chapman (Cyperaceae), and *Thalictrum cooleyi* Ahles (Ranunculaceae); see LeBlond et al. (1994) and LeBlond (2001) for a discussion of this remarkable ecosystem. The three localities cited under Specimens Examined occur within eight km of each other and are part of a complex of savannas that are remnants of a once larger ecosystem.

2. Coreopsis falcata F.E. Boynton, Biltmore Bot. Stud. 1(2):141. 1902.

This and *C. nudata* are the only spring/summer blooming species in the section and both have basally disposed leaves. *C. nudata* is easily distinguished by its pink to deep rosy ray ligules, terete leaves, and more southern distribution; the two species are allopatric. Seven out of 51 specimens at NCU lacked leaf lobes (or we could not see them clearly); hence this species is keyed twice. It features very short achene awns, averaging 0.5 mm; only those of *C. aristulata* are shorter. Furthermore, achenes of *C. falcata* are truncated at each end, unlike any other species. It inhabits seepage bogs, wet savannas, wet borrow pits, and seepy streamsides. *C. falcata* ranges from extreme southeastern Virginia [*Fleming and Caljouw 10435* (GMUF, WILLI)] to southern South Carolina (Fig. 4). It was reported for Georgia in McIntosh and Bibb Counties by Jones and Coile (1988) and there is a specimen at GH simply labeled "Georgia"; it is possibly more common in Georgia than these few records indicate. There is a single disjunct occurrence in the mountains of Oconee County, South Carolina ["Seneca", McCarthy s.n. (NCU)], which is far out of range but plausible if collected in a montane seepage bog. Flowering dates: early May–late June(–early Jul).

3. Coreopsis floridana E.B. Smith, Sida 6:192. 1976.

This is the only species with consistently short, deltoid outer phyllaries. It resembles narrow-leaved forms of *C. gladiata*, but achenes of *C. floridana* are proportionately shorter and broader, resulting in an elliptical shape rather than a narrowly elliptical or spindle shape. The lower leaves in the drawing in Smith (1976) represent the wide- and short-bladed end of the spectrum, whereas leaves of most plants are much longer and narrower, thus resembling *C. falcata*. These two species are amply distinguished by flowering period, length of outer phyllaries, and by the leaf lobes usually present in *C. falcata*. *Coreopsis floridana* inhabits wet savannas, flatwoods, and roadside ditches. It is endemic to Florida, ranging from Walton County to Dade County, absent from the north central and northeastern counties (Fig. 5). Flowering dates: late Sep–Feb.

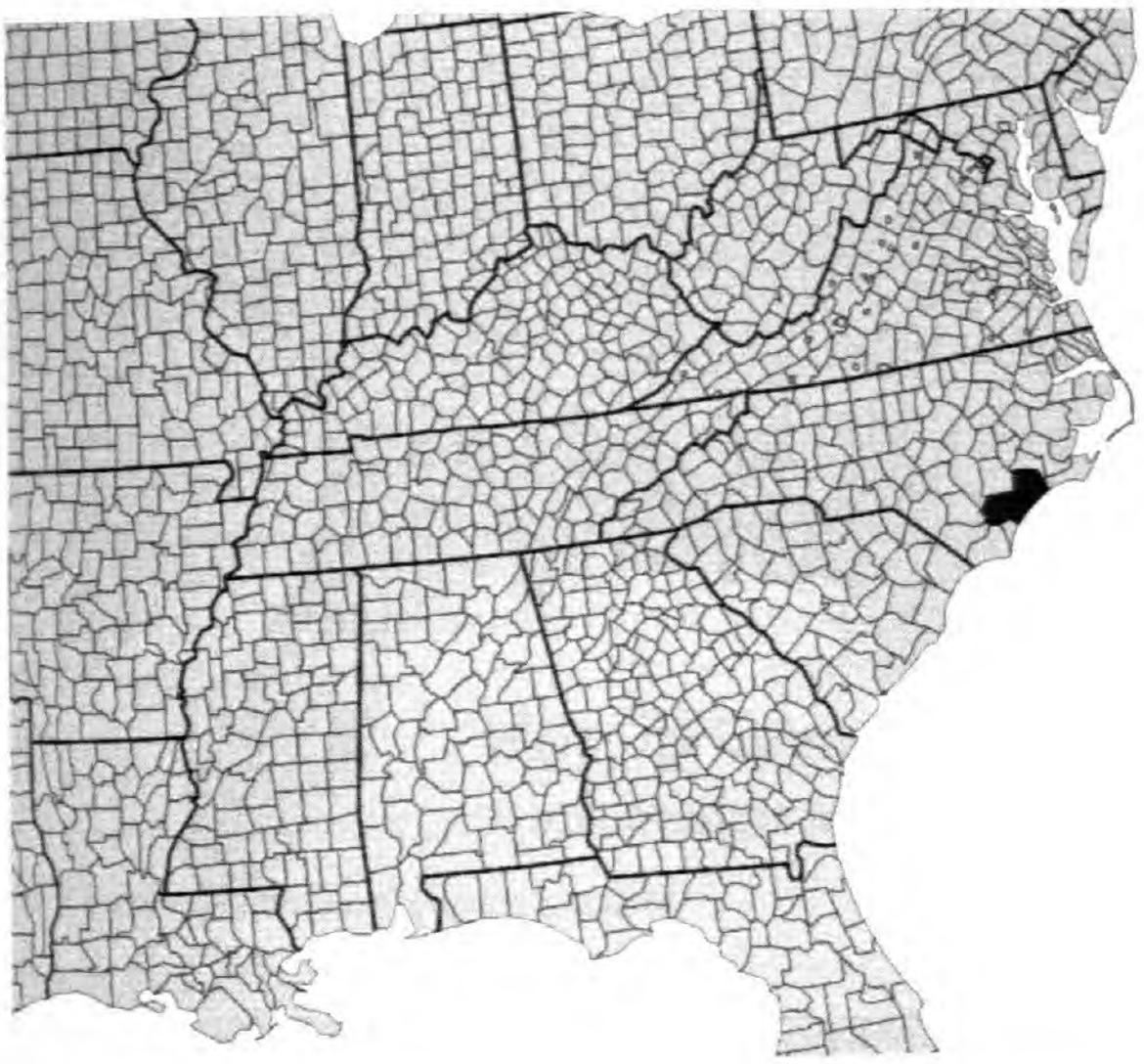


Fig. 3. Known distribution of *Coreopsis aristulata*.

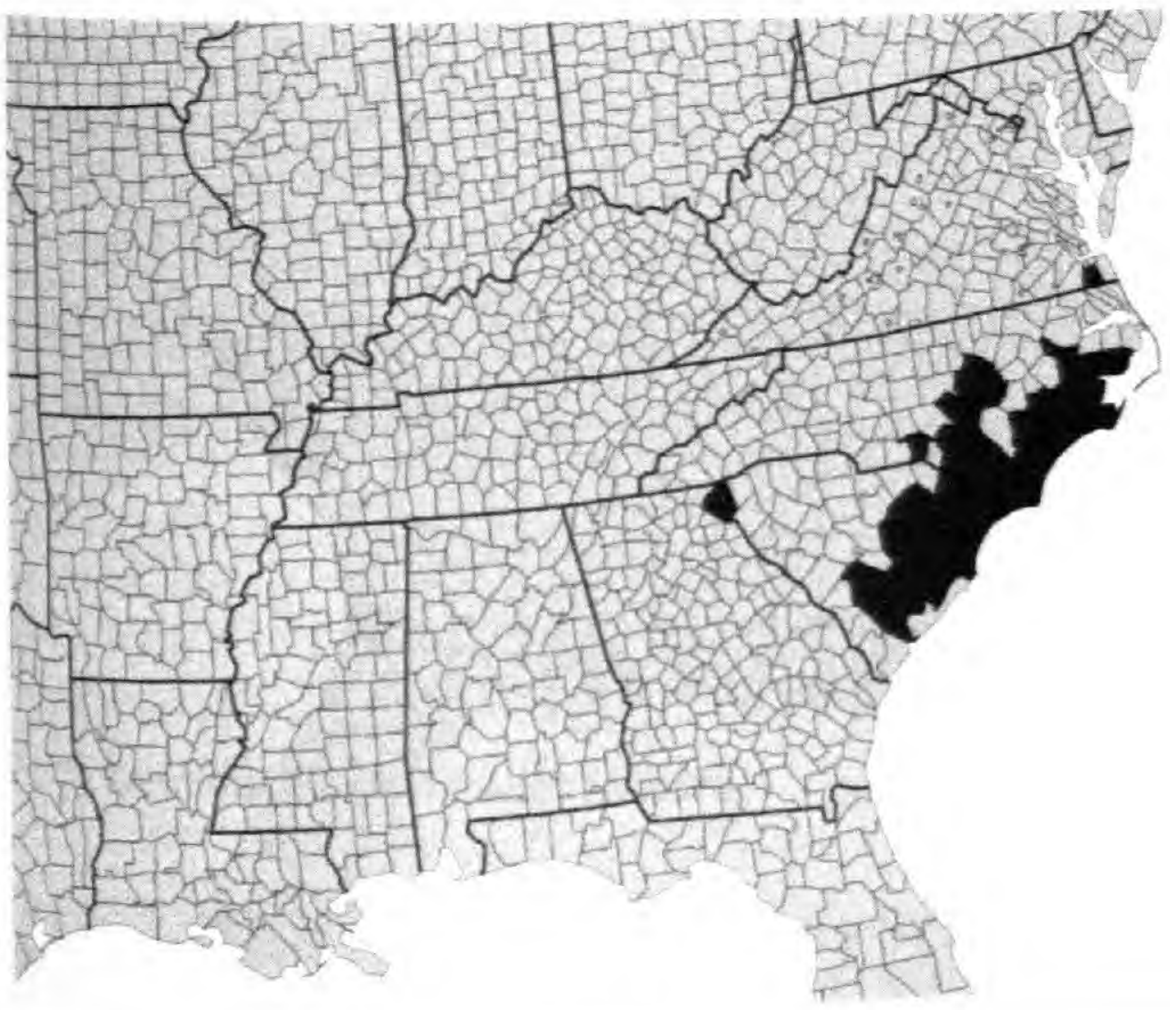


Fig. 4. Known distribution of *Coreopsis falcata*.



Fig. 5. Known distribution of *Coreopsis floridana*.

4. Coreopsis gladiata Walter, Fl. Carol. 215. 1788. Type: SOUTH CAROLINA. Georgetown Co.: grass-sedge bog or savannah, 12 mi N of Georgetown, 15 Sep 1939, *R.K. Godfrey* 8238 (neotype, designated by Smith 1976: F; isoneotypes MO!, TENN).

Coreopsis angustifolia Dryand, *C. dichotoma* Michx., *C. longifolia* Small, and *C. longifolia* var. *godfreyi* Sherff

Most plants have broadly elliptic basal and lower leaves and are strikingly distinct from all other taxa; only *C. palustris* (=*helianthoides*) may have similarly broad leaves, but those occur only in the mid-cauline region because the basal and lower leaves have senesced by anthesis. *Coreopsis gladiata* and *C. linifolia* have the longest achene awns of this group: 1.5 and 1.4 mm, respectively. Plants originally described as *C. longifolia* Small represent the narrow extreme of leaf width; achene morphology appears to be identical and we are unable to detect other differences. This narrow leaved variant appears more-or-less throughout the range, but is most often encountered in peninsular Florida. *Coreopsis gladiata* is most frequent in the East Gulf Coastal Plain, where it inhabits wet pitcher-plant bogs and streamhead seepages. Disjunct populations occur in the mountains of the Carolinas and Georgia, where they inhabit montane seepage bogs. *Coreopsis gladiata* ranges from eastern South Carolina to north Florida and southeastern Mississippi; disjunct to montane Georgia, South Carolina, and North Carolina (Fig. 6). It should be sought in southeastern Louisiana. Flowering dates: mid August–early November.

5. Coreopsis integrifolia Poir. ex Lam., Encycl. Suppl. 2, 352. 1811.

This species is distinctive in its strictly opposite, ovate, and uniformly small-bladed leaves. *Coreopsis integrifolia* is rare and local, known from six counties in northern Florida, five in southern Georgia, and four in southeastern South Carolina (Fig. 7). We have not been able to verify a report from North Carolina (Strother 2006). It inhabits semi-open floodplains and floodplain margins, powerlines and gaslines through swamp forests, and streamside seepages. This species appears to prefer calcareous soils. Flowering dates: mid August–early November.

6. Coreopsis linifolia Nutt., J. Acad. Nat. Sci. Philadelphia 7:75. 1834.

Coreopsis callosa Bertol., *C. gladiata* var. *linifolia* (Nutt.) Cronquist, *C. onisocarpa* Fernald, *C. onisocarpa* var. *simulans* Fernald, *C. saxicoloidea* Sherff

In the field this species and *C. rosea* usually are distinctly shorter than the other species in the section, much less than a meter tall. *Coreopsis gladiata* and *C. linifolia* have the longest achene awns of the group: 1.5 and 1.4 mm, respectively. The mid and upper stem leaves of *C. linifolia* are opposite, but lower leaves may be alternate; thus it is keyed twice. A unique character of *C. linifolia* is the presence of numerous dark dots on the leaf surfaces, seen best abaxially via transmitted light. Smith (1976) documents the existence of two chromosome races: a Gulf Coastal Plain diploid race (*linifolia*) and a southern Atlantic Coastal Plain tetraploid race (*onisocarpa*, originally described as C. onisocarpa by Fernald (1938)). The two races are separated by a slender gap between Leon County, Florida and Brooks County, Georgia; it is not known whether this gap is real or a collecting anomaly. Fernald treated the two races as species, but, like Smith, we are unable to discern any differences in achene, leaf, or floral morphology. *Coreopsis linifolia* has the widest range of any species in the section: southeastern Virginia to north Florida to east Texas (Fig. 8). Smith (1976) maps this species in Bartow County in northwest Georgia, but we have seen no voucher specimen. It inhabits moist to wet savannas, flatwoods, pitcher-plant bogs, and streamhead ecotones. Flowering dates: early Jul–late Oct.

7. Coreopsis nudata Nutt., Gen. N. Amer. Pl. 2:180. 1818.

With its basally disposed terete leaves and pink to deep rosy ray ligules, *C. nudata* is strikingly distinct. Along with *C. palustris*, it has the widest achene wings in the section, 0.3–0.5 mm. It ranges from southeastern Georgia to north Florida, west to southeastern Louisiana (Fig. 9). *Coreopsis nudata* inhabits pond cypress depressions, pond cypress stringers, wet roadside ditches, and intermittently ponded flatwoods. Flowering dates: late March to late May.

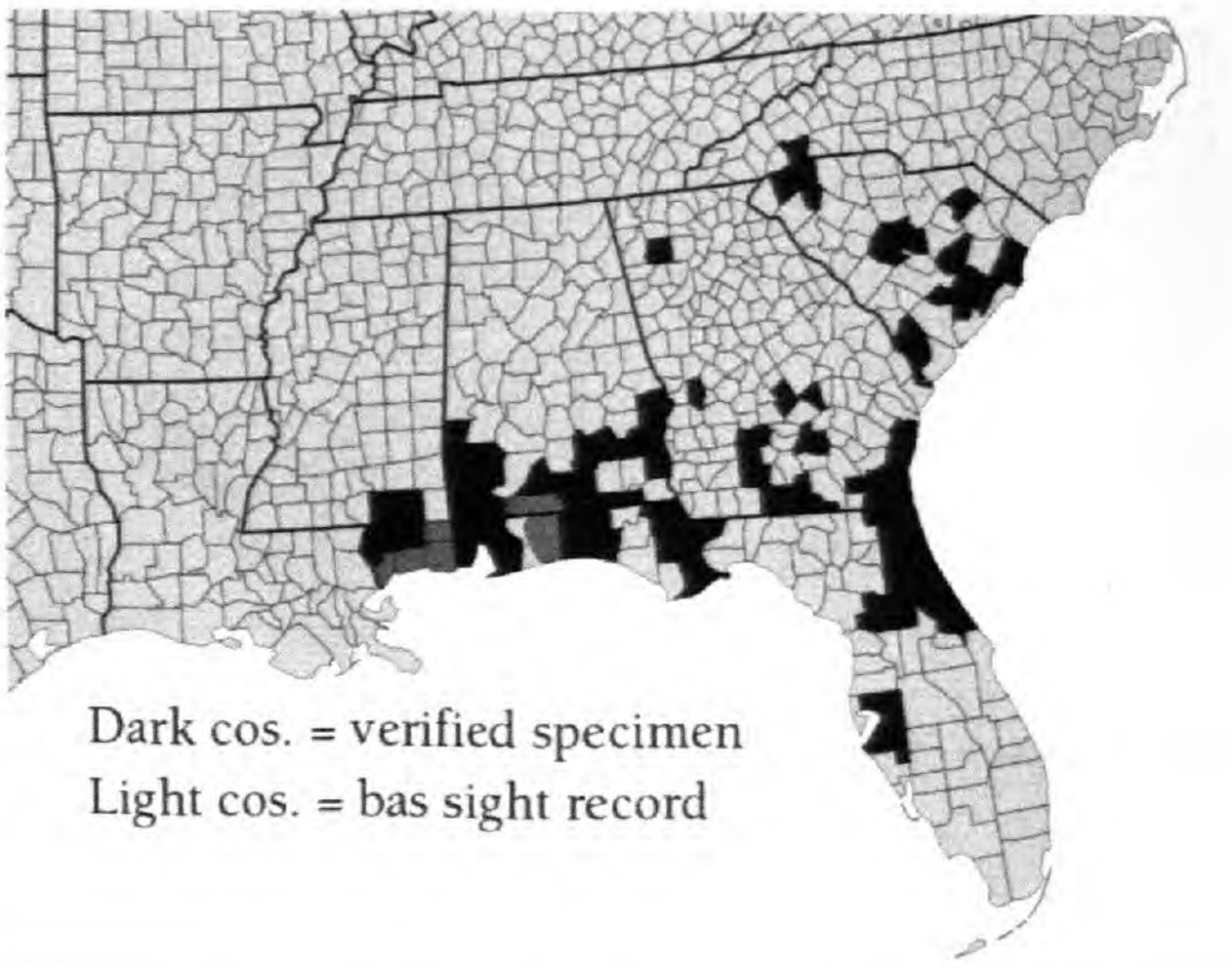


FIG. 6. Known distribution of *Coreopsis gladiata*.

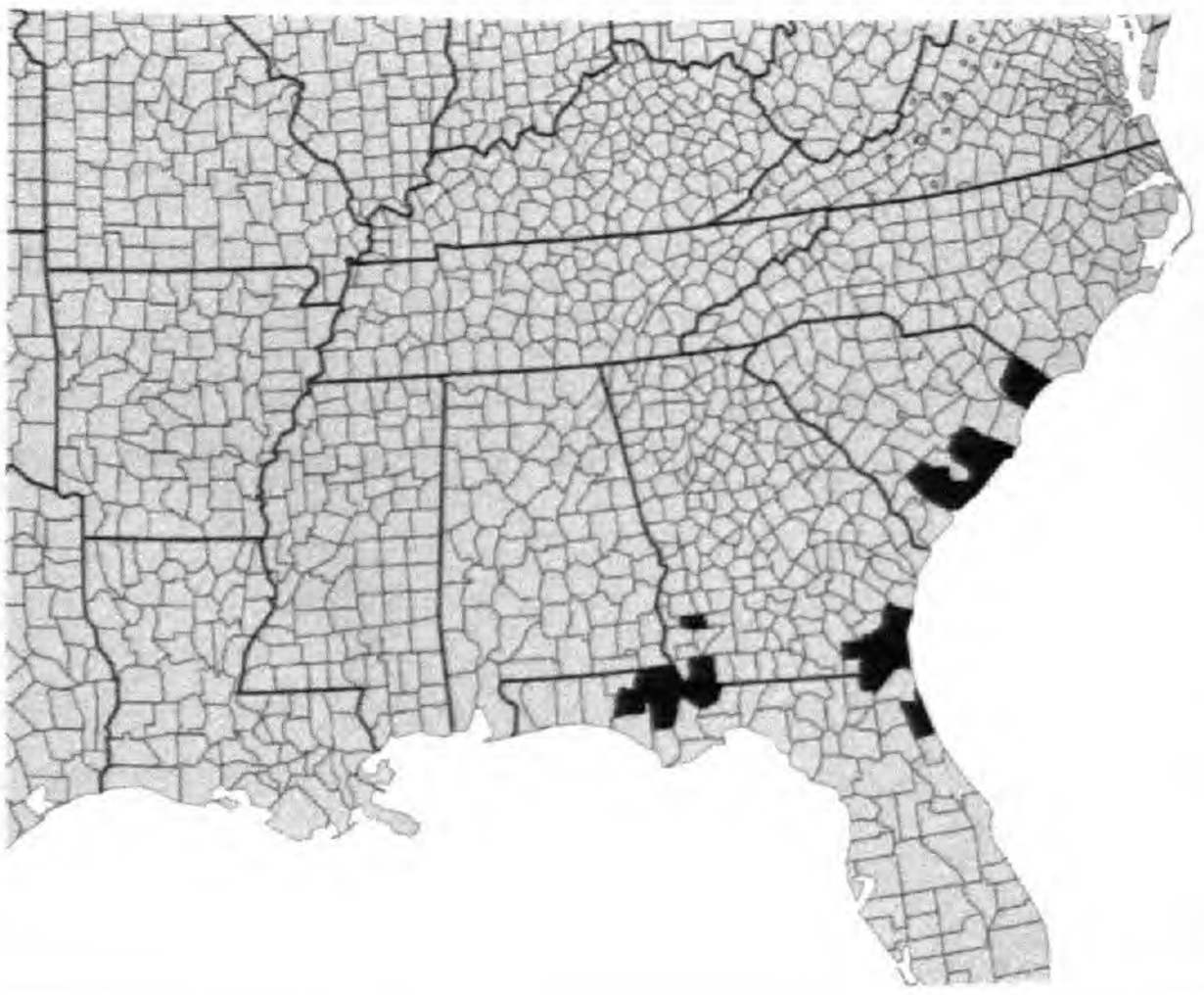


FIG. 7. Known distribution of *Coreopsis integrifolia*.

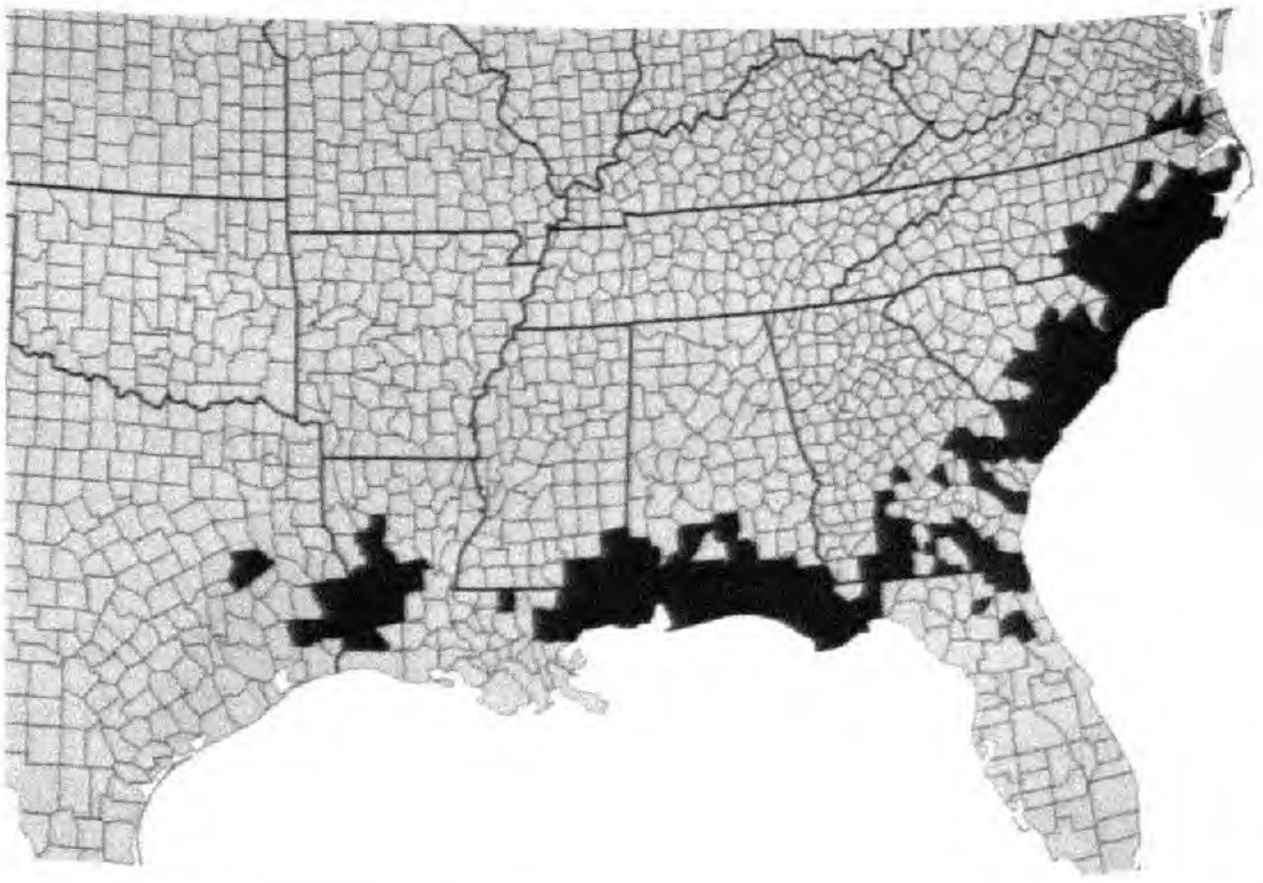


FIG. 8. Known distribution of *Coreopsis linifolia*.

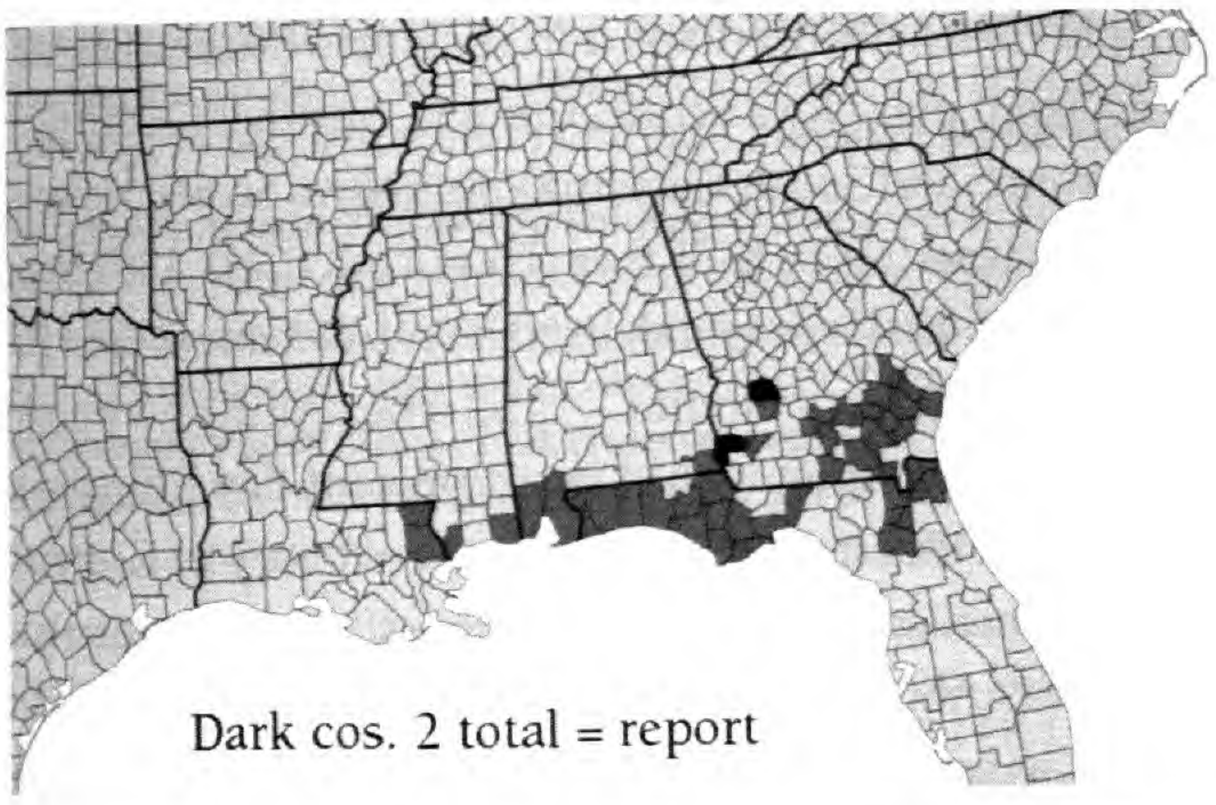


Fig. 9. Known distribution of *Coreopsis nudata*.

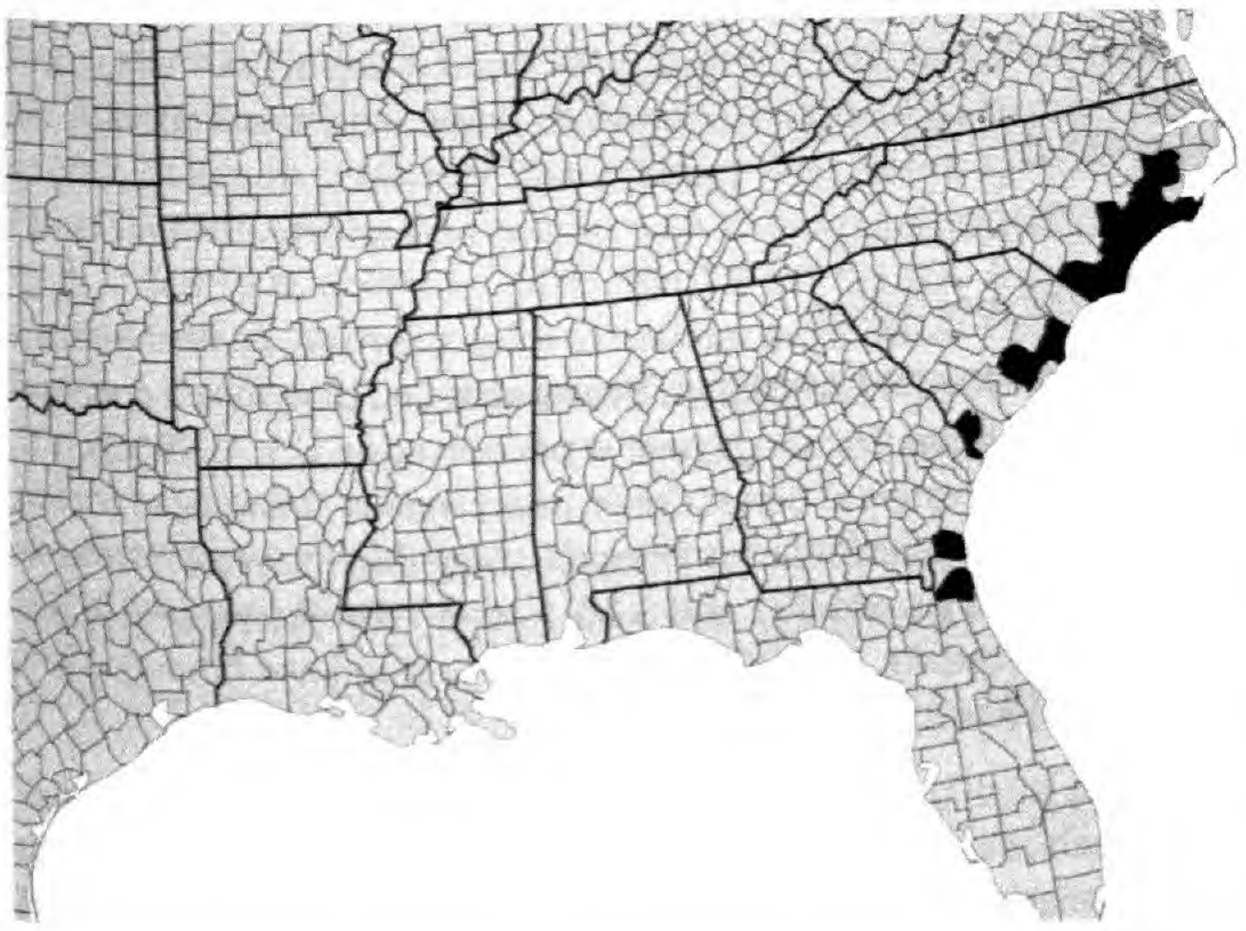


Fig. 10. Known distribution of *Coreopsis palustris*.



Fig. 11. Known distribution of *Coreopsis rosea*.

8. Coreopsis palustris Sorrie, J. Bot. Res. Inst. Texas 5:439. 2011.

Since its inception, *C. helianthoides* Beadle has been a misunderstood and often neglected species. In part this is due to the general paucity of specimens in herbaria and in part due to Beadle's erroneous protolog. Beadle (1898) designated a type [Aspalaga, Florida, October 1897, *A.W. Chapman s.n.* (Biltmore Herb., holotype perhaps destroyed; isotypes MO!, US!)], but the specimens actually are *C. gladiata* Walter, due to the presence of broad-bladed leaves at all basal and lower culm nodes, and collected hundreds of kilometers outside of the proven range of *C. helianthoides*. We recommend that the name *C. gladiata* Walter be conserved for Walter's plant; Smith has designated a neotype (see above). Therefore, the entity known as *C. helianthoides* has been assigned a new name: *C. palustris* Sorrie (Weakley et al. 2011). The salient features of this highly distinctive species have been overlooked by practically all authors except Radford et al. (1968). Its leaf phenology is matched only by *C. aristulata*, with the lower 4–6 leaves senescent or deciduous by anthesis, thus leaving the lower nodes essentially naked. *Coreopsis palustris* is notable for the very broad achene wings (0.5 mm), matched only by *C. nudata*. *Coreopsis palustris* often grows prostrate with ascending distal portions of stems, perhaps due to relatively frequent inundation; of the species in section *Eublepharis*, only *C. palustris* and *C. integrifolia* inhabit communities that are subject to river or stream overflow. *Coreopsis palustris* inhabits swamp forests and openings, fresh tidal creek margins, marshes, and borrow ponds. It ranges from southeastern North Carolina to Duval County, Florida (last collected there in 1898) (Fig. 10). Georgia specimens of *C. palustris* are extremely rare: Camden County, 1 mi N of Kingsland, 18 Oct 1950, *Godfrey 50908* (FSU, NCSC). Flowering dates: mid August–late October.

9. Coreopsis rosea Nutt., Gen. N. Amer. Pl. 2:179. 1818.

The distribution of no other species in section *Eublepharis* has been as under-represented in

manuals and monographs as that of *C. rosea*. For example, Smith (1976) maps it in six states (Massachusetts, Rhode Island, New York, New Jersey, Delaware, and Maryland) plus Nova Scotia, Canada. Strother (2006) lists six states (Massachusetts, Rhode Island, New Jersey, Delaware, and South Carolina) plus Nova Scotia. However, there are specimens dating as far back as 1903 from Maryland (MO), 1871 from New York (GH), 1865 from Pennsylvania (GH, MO), and 1900 from South Carolina (PH). Nuttall's original discovery was made in Georgia in October 1815: "about 20 mls. from Savannah on my way to Augusta I found ... and a beautiful new purple flowered species of *Coreopsis*!" (Graustein 1967, p. 101). This location would be in present-day Effingham County. Nuttall's original description of *C. rosea* clearly stated that it occurred "from New Jersey to Georgia" (Nuttall 1818, p. 179). Finally, there is a Leavenworth specimen collected in Georgia pre-1862 (Leavenworth s.n. PH), as reported by Smith (1978). Figure 11 shows the distribution by county. *Coreopsis rosea* is unique in the section in its very short and narrow achenes which lack wings and awns. The awnless achenes may suggest affinity with some other section of the genus, as was done by Sherff (1936)—section *Calliopsis*—but molecular data is needed to guide current decision-making. *Coreopsis rosea* inhabits sandy to stony shores of ponds, lakes, and other depressional wetlands, plus sandy margins of Waccamaw River, South Carolina. Flowering dates: mid Jul–late Sep.

APPENDIX 1

SELECTED SPECIMEN RECORDS

1. Coreopsis aristulata. All known specimens are listed above in the paratypes section.

2. Coreopsis falcata. GEORGIA: no county, location, or collector s.n. (GH). **NORTH CAROLINA. Brunswick Co.:** pine/mixed graminoid savanna on W side of rte. 211, Green Swamp, 14 Sep 1985, *Taggart 188* (NCU). **Jones Co.:** sandy peat at pocosin edge, U.S. 70, 28 May 1977, *Kral 60220* (USCH). **Richmond Co.:** Sandhills Game Land, Nursery Lane at headwaters of Bones Creek, peaty mud in streamhead pocosin, 3 Jun 1998, *Sorrie 9755* (NCU). **SOUTH CAROLINA. Berkeley Co.:** ponds in the pineland near Pinopolis, May–Jun [no year], *Ravenel s.n.* (USCH). **Colleton Co.:** savannah ecotone with *Collinsonia* and *Lobelia*, west of jct. of S-172 and S-28, 7 June 1984, *Rayner 1940* (USCH). **Oconee Co.:** Seneca, June 1888, *McCarthy s.n.* (NCU). **Virginia:** City of Chesapeake, inundated bald cypress woodland bordering fresh tidal marshes along Northwest River, 26 May 1995, *Fleming 10435* with Caljouw (GMUF, WILLI).

3. Coreopsis floridana. FLORIDA. Dixie Co.: common in low wet sandy ditch by U.S. alt. 27, 11.4 mi NW of Shamrock, 31 Oct 1974, *EB Smith 1840* (FSU, UARK, US). TYPE. **Franklin Co.:** low pine barrens, Apalachicola, 22 Sep 1879, *Biltmore Herb. 2066b and 2066c* [apparently Chapman collections] (MO, NCU, NY). **Polk Co.:** 20 mi E of Lake Wales at Fed Haven, flat undrained land, 29 Nov 1965, *Conard s.n.* (NCU).

4. Coreopsis gladiata. ALABAMA. Henry Co.: mucky bottoms of Foster Creek where crossed by Ala. 95, 18 Oct 1969, *Kral 37970* (FSU). **Mobile Co.:** shrubby to open seepage slope (poor fen) off CR 96, 18 Oct 1996, *Sorrie 9127* (NCU). **Washington Co.:** 5 mi S of Fruitdale, common in bog below oak-pine woods, 7 Oct 1967, *McDaniel 9906* (FSU). **FLORIDA. Duval Co.:** near Jacksonville, *Curtiss 4487* (MO). **Okaloosa Co.:** Blackwater River State Forest, abundant in sphagnous streamhead and roadside ditches by FR 50, 26 Oct 1998, *Sorrie 10043* with LeBlond (NCU). **GEORGIA. Bartow Co.:** muddy open area at edges of large spring just S of Aubrey Lake, 19 Sep 1951, *Duncan 13189* (MO, NCSC). **Glynn Co.:** edge of wet woods, rte. 99, 4 Oct 1982, *Angerman s.n.* (USCH). **Turner Co.:** sandy peat of pineland bog by Ga. 32, 5.2 mi W of Ga. 125, 25 Sep 1975, *Kral 56823* (MO). **MISSISSIPPI. Forrest Co.:** bog in longleaf pine, 1–2 mi SW of Geiger Lake, Johnson State Park, 25 Oct 1971, *Rogers 7137-G* (MO). **Pearl River Co.:** 2 mi N of Picayune, open sphagnum bog, 4 Oct 1968, *Sargent 9787* (MO). **Perry Co.:** abundant in hillside seepage bog with *Parnassia grandifolia* and *Rhynchospora macra*, Camp Shelby Impact Area, 19 Sep 1996, *Leonard 12310* (NCU). **NORTH CAROLINA. Henderson Co.:** in bog, East Flat Rock on rte. 176, 10 Aug 1937, *Coker s.n.* (NCU). **SOUTH CAROLINA. Berkeley Co.:** Francis Marian National Forest, roadside N of Red Bluff Creek, 24 Oct 1995, *Marshall 44 with Porcher* (USCH). **Greenville Co.:** Double Springs piedmont seepage forest, 15 Oct 1999, *Pittman 10159903* (MO, USCH). **Richland Co.:** Fort Jackson, Buffalo Creek Natural Area, 31 Oct 1995, *Pittman 10319504* (USCH).

5. Coreopsis integrifolia. FLORIDA. Calhoun Co.: wooded banks of Chipola River by rte. 20 W of Blountstown, 18 Oct 1990, *Godfrey 84014* (GH). **Nassau Co.:** Brandy Branch Swamp, S of Bryceville, 24 Sep 2000, *Anderson 19485* (MO). **GEORGIA. Calhoun Co.:** on slopes a few feet above water level, 30 Oct 1974, *EB Smith 1838* (FSU). **SOUTH CAROLINA. Charleston Co.:** S end of Cox Road, 2.5 mi NNW of Parkers Ferry, 22 Sep 2004, *Nelson 25076* (USCH). **Horry Co.:** abundant on a silt bar on shore of Waccamaw River, SW of S-31 bridge, Red Bluff Landing, 10 Oct 1985, *Rayner 2248B* (USCH).

6. Coreopsis linifolia. ALABAMA. Geneva Co.: roadside and savanna south of jct. of highway 53 and 153, 25 Aug 1966, *Clark 7682* (NCU). **Washington Co.:** low area in pineland ca. 4 mi N of Topton, 3 Oct 1966, *Clark 8818* (NCU). **FLORIDA. Leon Co.:** roadside along Helen Guard Station Road about 15 mi S of Tallahassee, 13 Sep 1993, *Henderson 93-325* (MO). **Putnam Co.:** frequent in moist loamy sand of roadside depression along rte. 19, N side of Palatka, 15 May 1997, *Anderson 17437* (FSU). **GEORGIA. Cook Co.:** low seepage area (pitcher plant bog) alongside Ga. 76, 2.7 mi NE of Barney, 21 Sep 1965, *Faircloth 3002* (NCU), **McIntosh Co.:** along the grassy edge of the road, route 17, 4 mi N of Darien, 4 Oct 1982, *Angerman s.n.* (USCH). **LOUISIANA. Natchitoches Parish**: large hillside bog beside FS 380, Kisatchie National Forest, 17 Sep 1988, *Thomas 107284* (MO). **MISSISSIPPI. Harrison Co.:** savanna 2 mi N of Gulfport, 14 Sep 1966, *Jones, Jr. 10347* (NCU). **Lamar Co.:** longleaf pine woods 8 mi W of Hattiesburg, 13 Sep 1964, *Jones, Jr. 2488* (NCU). **NORTH CAROLINA. Carteret Co.:** Croatan National Forest, grass savanna on Millis Road, 4 Oct 1975, *Wilson 1564* (NCU). **Harnett Co.:** seep in longleaf pine hills, N side of Spout

Springs, 18 Sep 1977, *Kral 60960* (MO). **South Carolina. Charleston Co.:** cut-over savannah, 2 Aug 2002, *Nelson 23113* (USCH). **Hampton Co.:** flat pine woods 0.8 mi NW of Brighton, then 0.8 mi WSW, 9 Sep 1956, *Bell 18242* (NCU). **TEXAS. Houston Co.:** Grapeland, sandy open bogs, 16 Sep 1918, *Palmer 14418* (MO). **VIRGINIA. Nansemond Co.:** boggy area ½ mi W of Kilby, 28 Sep 1967, *Harvill 17521* (MO).

7. Coreopsis nudata. ALABAMA. Baldwin Co.: very wet grassy area E of Gulf Shores, 1 May 1965, *Koelling 2199* (NCU). **Florida. Alachua Co.:** wet depression near Fairbanks, 6 Apr 1938, *Correll 8944* (DUKE). **Okaloosa Co.:** Eglin Air Force Base, cypress-Hypericum pond just SW of Test Facility 121, 16 May 1996, *Sorrie, LeBlond, Chafin* sight record. **GEORGIA. Brantley Co.:** shallow water of flats by road from Brunswick to Waycross, May 1933, *Coker s.n.* (NCU). **Tattnall Co.:** wet pine barrens near Collins, 4 Jul 1901, *Harper 1001* (GH). **LOUISIANA. St. Tammany Parish**: Abita Creek Preserve, wet savanna, 1996, *Smith & McInnis* (LA Natural Heritage Program database). **MISSISSIPPI. Hancock Co.:** 0.5 mi N of Dead Tiger Creek, 26 Apr 1981, *McDaniel 24970* (FSU). **Jackson Co.:** grassy roadside ditch in Pinus palustris savanna, U.S. 90 W of Pascagoula, May 1954, *Wood, Jr.* 8462 (NCU).

8. Coreopsis palustris. FLORIDA. Duval Co.: border of low thicket near Jacksonville, 5 Nov 1898, *Curtiss 6302* (NCU). **GEORGIA. Camden Co.:** 1 mi N of Kingsland, 18 Oct 1950, *Godfrey 50908* (FSU, NCSC). **NORTH CAROLINA. Brunswick Co.:** clearing bordering swamp forest and on stream bank, Bell Swamp near Winnabow, 27 Oct 1950, *Godfrey 50957* (holotype: NCSC; isotypes FSU, MO). **Jones Co.:** marsh on Trent River, 5 mi NE of Pollocksville, 4 Oct 1953, *Radford 7684* (NCU). **SOUTH CAROLINA. Berkeley Co.:** swamp forest along CR 172, 18 Oct 1968, *Leonard 2162* (USCH). **Jasper Co.:** boggy meadow on SC 652, 9 Oct 1987, *Uttal 14847* (NCU).

9. Coreopsis rosea. NOVA SCOTIA. Yarmouth Co.: peaty and cobbly beach of St. John (Wilson's) Lake, 23 Jul 1921, *Fernald 24687* (GH). **DELAWARE. Sussex County**, shore of Tubbs Pond, Milford, 10 Sep 1931, *Goodale s.n.* (DUKE). **GEORGIA:** no data, *Leavenworth s.n.* (PH). **MARYLAND. Caroline Co.:** Denton, 21 Aug 1903, *Norton s.n.* (MO). **MASSACHUSETTS. Dukes Co.:** in shallow water of Seth's Pond, West Tisbury, Martha's Vineyard, 7 Sep 1917, *Seymour 1384* (GH). **Plymouth Co.:** in sandy flooded places, 1842, *Oakes s.n.* (GH, MO). **NEW JERSEY. Atlantic Co.:** ditches along abandoned railroad, Egg Harbor City, *Mackenzie 8049* (NCU). **Cumberland Co.:** Millville, Hankens Pond on Petticoat Branch of Maurice River, 15 Aug 1926, *Adams 480* (GH). **NEW YORK. Suffolk Co.:** Artist's Lake, 14 Aug 1923, *House 9660* (GH). **PENNSYLVANIA. Bucks Co.:** swamp near Bristol, 11 Aug 1865, *Parker s.n.* (MO). **RHODE ISLAND. Providence Co.:** Lincoln, Spectacle Pond, 11 Sep 1900, *Collins s.n.* (GH). **SOUTH CAROLINA. Aiken Co.:** sink margins E of Monetta, 1971, *Massey 2983* (NCU). **Horry Co.:** scattered in small patches, partial to full sun, moist grassy habitat, E side of Waccamaw River at rte. 9, 18 Oct 1980, *Leonard 7447* (FSU).

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ARCEUTHOBIUM GILLII AND *A. NIGRUM* (VISCACEAE) REVISITED: DISTRIBUTION, MORPHOLOGY, AND rDNA-ITS ANALYSIS

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ABSTRACT

Additional morphological, phenological, and molecular data were obtained for *Arceuthobium gillii* and *A. nigrum* from throughout their geographic distributions in northern Mexico and southern Arizona. Multivariate analysis of variance (MANOVA) and discriminant function analysis demonstrated that *A. gillii* and *A. nigrum* are distinguishable morphologically. Discriminant function analysis also indicated that the dimensions of the third internode (length and width) and basal diameter of female and male plants contributed most to the classification and predication of species. Significant differences in plant height (female and male) as well as flower and fruit dimensions were also evident between these dwarf mistletoes, *A. nigrum* having larger dimensions for each of these characters. Although *A. nigrum* purportedly flowers twice annually (spring and fall), our observations indicated that the period of anthesis for this mistletoe occurs only once annually—fall to early winter. In contrast, *A. gillii* flowers in the spring; thereby, suggesting that these taxa likely are reproductively isolated. Phylogenetic analyses of nucleotide sequences of the rDNA internal transcribed spacer (ITS) region delineated both taxa, resolving *A. gillii* to a monophyletic clade strongly supported by bootstrap and Bayesian credibility values. Collectively, *A. gillii* and *A. nigrum* are well-defined morphologically and distinguishable molecularly, supporting the classification of these taxa at the specific rank.

KEY WORDS: dwarf mistletoe, hosts, MANOVA, *Pinus chihuahuana*, *Pinus leiophylla*, taxonomy

RESUMEN

Se obtuvieron datos adicionales morfológicos, fenológicos y moleculares para *Arceuthobium gillii* y *A. nigrum* en sus distribuciones geográficas del norte de México y Sur de Arizona. Se usó un análisis multivariante de varianza (MANOVA) y análisis de funciones discriminantes para demostrar que *A. gillii* and *A. nigrum* son diferentes morfológicamente. El análisis discriminante también indicó que las dimensiones del tercer internudo (longitud y ancho) y el diámetro basal de las plantas masculinas y femeninas contribuyeron en su mayoría a la clasificación y predicción de las especies. Se encontraron diferencias significativas en la altura de las plantas (femeninas y masculinas) así como en el color de la flor y las dimensiones del fruto entre estas dos especies de muérdago enano; *A. nigrum* presenta las dimensiones más grandes para cada uno de estos caracteres. Aunque supuestamente *A. nigrum* florece dos veces al año (primavera y otoño), nuestras observaciones indicaron que el periodo de antesis para este muérdago ocurre solamente una vez al año—otoño o inicios del invierno. En contraste, *A. gillii* florece en la primavera, sugiriendo que estos taxa se reproducen aisladamente. Un análisis filogenético de los espaciadores internos transcritos del ADN ribosomal separó a los dos grupos taxonómicos. *A. gilli* formó un grupo monofilético con buen soporte de bootstrap y valores de inferencia Bayesiana. En conclusión, la clasificación taxonómica de *A. gilli* y *A. nigrum* está bien sustentada con base en una buena definición de su morfología y en secuencias de ADN.

PALABRAS CLAVE: muérdago enano, huéspedes, MANOVA, *Pinus chihuahuana*, *Pinus leiophylla*, taxonomía

Gill's dwarf mistletoe, *Arceuthobium gillii* Hawksworth & Wiens (Santalales: Viscaceae), was described in 1964 from southern Arizona (Hawksworth & Wiens 1964). Previously, *A. gillii* was often misdiagnosed as *A. vaginatum* (Willdenow) Presl subsp. *cryptopodum* (Engelmann) Hawksworth & Wiens (southwestern dwarf mistletoe) or *A. divaricatum* Engelmann (pinyon pine dwarf mistletoe) in southeastern Arizona and northern Mexico, where these mistletoes are sympatric (Blumer 1910; Gill 1935; Hawksworth & Wiens 1964, 1972). *Arceuthobium gillii* can be readily distinguished morphologically and physiologically from the latter species by its shoot color and sexual dimorphism, highly glaucous fruits, host preferences, and time of anthesis (Hawksworth & Wiens 1964, 1996). Another similar dwarf mistletoe to *A. gillii* is *A. nigrum* Hawksworth & Wiens (black dwarf mistletoe) which was initially described as a subspecies of *A. gillii* (Hawksworth & Wiens 1965) as both taxa produce glaucous fruits, sexually dimorphic shoots, and share principal hosts in northern Mexi-

co—*Pinus leiophylla* Schiede ex Schlechtendal & Chamisso, *P. chihuahuana* Engelmann, and *P. lumholtzi* B.L. Robinson & Fernald. However, *A. nigrum* was raised to the specific rank by Hawksworth and Wiens (1989) based on morphological discontinuities with *A. gillii*; particularly, its larger and dark-green to black plants. Moreover, *A. nigrum* reportedly has two flowering periods (March–April and September–October; Hawksworth & Wiens 1989) while *A. gillii* flowers once annually (March–April; Hawksworth & Wiens 1996). Nevertheless, these species remain difficult to distinguish from each other particularly in high-elevation pine forests of central Durango, Mexico (Hawksworth & Wiens 1989, 1996; Mathiasen et al. 2008).

Because of the morphological similarities and host affinities of *A. gillii* and *A. nigrum* in northern Mexico, the geographic distribution of these dwarf mistletoes has remained unclear (Mathiasen et al. 2003, 2008, 2010). We, therefore, have been gathering additional morphological measurements and phenological observations since 1999 from Mexico as well as southern Arizona. According to previous work by Nickrent et al. (1994, 2004), *A. gillii* and *A. nigrum* can be readily distinguished molecularly via DNA analysis of the nuclear ribosomal internal transcribed spacer (nrITS) region. Therefore, we examined newly generated ITS sequences for *A. gillii* and *A. nigrum* to better assess species boundaries and the geographic distribution of these mistletoes in Mexico. Herein, we report the discriminatory morphological characters and phenology differences between *A. gillii* and *A. nigrum* as well as our nrITS analyses for both species across much of their geographic ranges.

METHODS

Morphological and Phenological Comparisons

To compare intra- and interspecific morphological characteristics of *A. gillii* and *A. nigrum*, we sampled 7 populations of *A. gillii* in southern Arizona and northern Mexico and 15 populations of *A. nigrum* from central and northern Mexico (Fig. 1). Plants were also collected and measured from the type localities (populations) for *A. gillii* and *A. nigrum* in Cochise County, Arizona, and Durango, Mexico, respectively (Hawksworth & Wiens 1964, 1965) (Fig. 1; locations 3 and 9). Ten to twenty male and female plants were collected and the dominant shoot from each plant was used for morphometric analyses. Plant characters measured were those used previously by Hawksworth and Wiens (1996) for the taxonomic classification of *Arceuthobium* spp.: (1) height, basal diameter, third internode length and width, and color of male and female plants; (2) mature fruit length, width, and color; (3) seed length, width, and color; (4) length and width of staminate spikes; (5) staminate flower diameters for 3- and 4-merous flowers as well as the length and width of petals; and, (6) anther diameter and distance from the petal tip. Each plant was measured less than 24-h after collection using a digital caliper, a dissecting microscope with a micrometer, or with a Bausch and Lomb 7× hand lens equipped with a micrometer. Staminate spike and flower measurements were made during peak anthesis, and fruit and seed measurements were made during the height of seed dispersal. Because the seasonal occurrence of flowering and seed dispersal for *A. gillii* and *A. nigrum* has received little attention (Hawksworth & Wiens 1996), phenological surveys for each taxon were conducted during the spring and fall of 1999, 2003, 2005, 2007, 2008, and 2010 as well as spring 2011.

A suite of multivariate and univariate statistical tests were utilized to assess species differences, collectively and separately, among the 20 morphological characteristics measured for *A. gillii* and *A. nigrum*. A one-way multivariate analysis of variance (MANOVA) was performed to control for experiment error (family-wise Type I error) and determine whether differences existed between the collective morphology of *A. gillii* and *A. nigrum* (Rancher 2002). One-way analysis of variance (ANOVA) was then used separately to examine the variance in the individual morphological characters of *A. gillii* and *A. nigrum*, and significant differences between means were determined using a posteriori contrast comparisons ($\alpha = 0.05$). Morphological data were also analyzed using discriminant function analysis (DFA; Quinn & Keough 2006) to determine how well each of the 20 morphological characteristics can be used to classify and predict species membership—*A. gillii* or *A. nigrum*. In addition, standardized discriminant function coefficients (DFC) were calculated to determine the relative importance of each morphological characteristic as a discriminator between species. Univariate and multivariate statistical analyses were performed using JMP 8 and JMP Pro 10 software (SAS Institute), respectively.

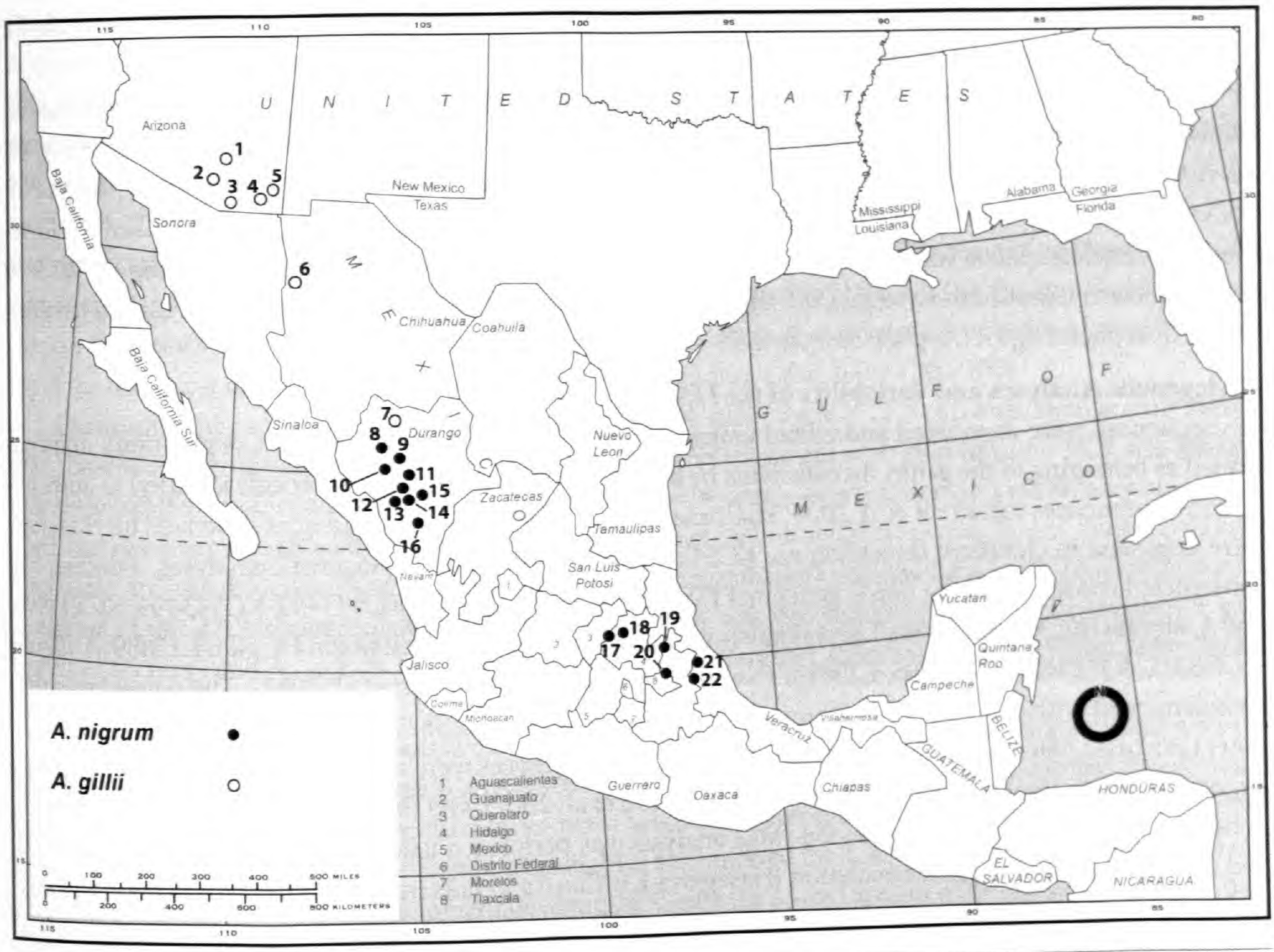


Fig. 1. Approximate locations of populations sampled for *Arceuthobium gillii* (open circles) in Arizona and Mexico and *A. nigrum* (dark circles) in Mexico. Localities from which plant material was collected for rDNA-ITS analysis (Fig. 4) are highlighted in bold. *A. gillii*: ARIZONA. **1** – Bear Canyon, Santa Catalina Mountains (RLM 1029, KC543492); **2** – Gardner Canyon, Santa Rita Mountains; **3** – 0.3 km E of the Reef, Huachuca Mountains (RLM 1027, KC543493); **4** – West Turkey Creek Campground, Chiricahua Mountains (RLM 1024, KC543494); **5** – Herb Martyr Picnic Area, Chiricahua Mountains (RLM 1023, KC543496); MEXICO. Chihuahua: **6** – 13 km E of Sonora state line on Route 16; Durango: **7** – 2 km E of La Quebrada. *A. nigrum*: MEXICO. Durango: **8** – 18 km W of Tepehuanes on rd. to Huacal; **9** – 50 km E of El Salto on Route 40 (RLM 0778, JQ723483); **10** – 11 km E of El Salto on Route 40 (RLM 0779, JC723481); **11** – 3 km E of El Salto on Route 40 (RLM 1105, KC543495); **12** – 23 km N of Route 40 on road to San Miguel de Cruces (RLM 0781, JQ723484) ; **13** – 102 km N of Route 40 on road to San Miguel de Cruces; **14** – 2 km N of Otinapa; **15** – 30 km W of Santiago Pasquiaro on road to Altares; Veracruz: **16** – Cofre de Perote 4 km S of Perote (RLM 0764, JQ723482); **17** – 3 km S of Sierra de Aqua on road to Pescados (RLM 1082, JQ723485); Puebla: **18** – 3 km NW of Los Hermanos; **19** – 6 km E of Route 119 on road to Tetla de Ocampo; Hidalgo: **20** – 5.5 km SW of Durango on Route 85 near Los Duraznos; **21** – 7 km NE of Metepec on road to Tenango de Doria.

PCR-amplification and Sequencing of the ITS region

Whole-genomic DNA was extracted from the aerial shoots of *A. gillii* (n = 4) and *A. nigrum* (n = 1) using a DNeasy® Plant Maxi Kit (Qiagen) and following the manufacturer's instructions; geographic location and voucher information are presented in Figure 1. Full-length, ITS sequences (partial 18S rRNA gene; complete ITS1, 5.8S rRNA gene, and ITS2; and, partial 26S rRNA gene) were PCR-amplified using the primer pair 18s 1830 for and 26S 40rev (Nickrent et al. 2004). PCR amplifications were performed in a total volume of 25 µL consisting of 2.5 µL 1X AccuPrime™ PCR buffer II (Invitrogen™; 600 mM Tris-SO_4 [pH 8.9], 180 mM $[NH_4]_2SO_4$, 20 mM $MgSO_4$, 2 mM dNTPs, thermostable AccuPrime™ protein, 10% glycerol), 0.5 µL (10 µM) of each primer (18s 1830 for and 26S 40rev), 0.1µL AccuPrime™ *Taq* DNA polymerase High Fidelity (Invitrogen™), 20.9 µL nuclease-free water (Promega), and 0.5 µL undiluted, genomic DNA (22–45 ng/µL). PCRs were performed using either a Eppendorf Mastercycler® Pro or Bio-Rad T100™ thermal cycler with identical cycling parameters: initial hold for 6 min. at 95°C; 5 cycles at 94°C for 30s, 55°C for 30s, and 72°C for 1 min.; 33 cycles at 94°C for 30s, 48°C for 30s, and 72°C for 1 min.; and, final extension step of 72°C for 10 min. Positive

controls and blank reactions (i.e., minus genomic DNA) were also included in each PCR run as checks for cross- and environmental contamination of template DNA, respectively.

Amplicon size for individual PCR products was checked via electrophoresis in 1.2% (wt/vol) agarose gels followed by ethidium bromide staining (1.2 mg/L 0.5X Tris-acetate-EDTA [TAE]) and visualization under ultra-violet fluorescence. PCR product(s) of *A. gillii* and *A. nigrum* were purified using the Wizard® Preps PCR DNA purification system (Promega) and the reagent ExoSAP-IT® (USB Inc.; 0.4 µL/µL of amplified DNA), respectively. Each amplicon was normalized (130 ng/reaction) and sequenced bidirectionally using an ABI 3730 DNA sequencer (Applied Biosystems), the referred primers (18s 1830 for and 26S 40rev), and a BigDye terminators DNA sequencing kit (Applied Biosystems).

Phylogenetic Analyses and Variability of the ITS

ITS sequences were assembled and edited using CodonCode Aligner (CodonCode Corporation), and confirmed as belonging to the genus *Arceuthobium* by BLASTN and comparison (nucleotide identity) to authenticated ITS sequences (Nickrent et al. 2004; Mathiasen et al. 2012). New DNA sequences generated for this study were deposited in GenBank (accession no. KC543492-KC543496). For phylogenetic analyses, a dataset was constructed consisting of the newly generated ITS sequences for *A. gillii* (KC543492-KC543494, KC543496) and *A. nigrum* (KC543495) as well as previously published sequences of each taxon (*A. gillii* L25689; *A. nigrum* AY288271, JQ723481-JQ723485, L25693) (Nickrent et al. 2004; Mathiasen et al. 2012). The dataset was then complemented with ITS sequences (outgroups) of *A. oaxacanum* (AY288273) and *A. yecorense* (AY288288) – sister taxa to *A. gillii* and *A. nigrum* (Nickrent et al. 2004). Sequences were aligned with the multiple sequence alignment option implemented in Clustal X v2.1 (Larkin et al. 2007), and the final alignment inspected in CodonCode Aligner. Maximum-likelihood (ML) analysis was performed using PAUP* 4.0b10 (Swofford 2003) and the best model of sequence evolution (Hasegawa-Kishino-Yano plus invariant sites [HKY+I]; Hasegawa et al. 1985) selected by the Akaike Information Criterion (AIC; Akaike 1974) as implemented in jModeltest 0.1.1 (Posada 2008). Likelihood settings corresponding to the HKY+I model were as follows: lset base = (0.3026 0.1618 0.2074), nst = 2, tratio = 2.5765, rates = equal, and pinvar = 0.7820. All nucleotides were included in the phylogenetic analysis and gaps were treated as missing characters. The heuristic search was performed with 1000 random-addition-sequence replicates (RAS), tree bisection-reconnection (TBR) branch swapping, and MULTREES in effect. Branch support was evaluated using 1000 bootstrap replicates and 100 RAS per pseudo-replicate.

Bayesian inference of phylogeny via the Markov Chain Monte Carlo (MCMC) method was also performed using MrBayes 3.1.2 (Huelsenbeck & Ronquist 2001) as well as the best model and associated likelihood parameters executed in ML tree reconstruction. One cold and three heated Markov chain(s) were run, and samples were taken every 100 generations over 5.0×10^6 generations for a total of 50,000 sampled generations. The potential scale reduction factor (PSRF) for each of the model parameters was >1.0 when the program was terminated. Stationarity was accessed by examining the average standard deviations of split frequencies and likelihood values. Burn-in value (10%) was determined using Tracer v1.5 (Rambaut & Drummond 2009); removing 5000 burnin (sampled) generations. The remaining trees were utilized to calculate a 50% majority rule consensus tree and to determine the posterior probabilities.

To assess inter- and intraspecific variability of the ITS for *A. gillii* and *A. nigrum*, mean pairwise genetic distances (HKY+I) were calculated using the custom distance matrix option in PAUP*and the statistical software JMP^R Pro 10. Mean nucleotide difference (n) and the physical characteristics (substitution sites) of the ITS sequences within and between species were also assessed in Geneious R6 (Biomatters Ltd.) and CodonCode Aligner.

RESULTS AND DISCUSSION

Morphometry

Significant differences in morphology were found between *A. gillii* and *A. nigrum* (MANOVA, Wilks' Lambda = 0.00579 (20, 179) = 1536.34; $P<0.0001$) with the former consistently producing smaller plants/plant parts

(Table 1). Discriminant function analysis indicated that the most important morphological traits delineating *A. gillii* and *A. nigrum* were the third internodal length of female plants (DFC = -7.97), basal diameter of male (DFC = 5.53) and female plants (DFC = -5.03), and, the third internodal width of female (DFC = 3.95) and male plants (DFC = 3.81). Other morphological characteristics such as the diameter of 4-merous flowers (DFC = 2.51), female plant height (DFC= -2.29), staminate spike length (DFC = -2.13), male plant height (DFC = -2.13), seed length (DFC = -1.93), third internodal length of male plants (DFC = 1.68), and anther diameter (DFC = 1.0) also significantly contributed to the discrimination of *A. gillii* and *A. nigrum*. The remaining flower, fruit, and seed characteristics contributed the least to the discriminant function (DFC< |1.0|). Percent classification to the correct species using either a full-model (all 20 morphological characteristics) or reduced-model consisting of the five, most discriminative characteristics described above was 100% (200/200).

Examining the morphometric results, male plants of *A. gillii* (mean = 12.3 cm) were significantly shorter than those of *A. nigrum* (mean = 24.3 cm). Similarly, female plant height of *A. gillii* (mean = 14.2) was also significantly smaller than female plants of *A. nigrum* (mean = 19.6 cm)—approximately 5 cm shorter on average. The basal diameter and third internodal length and width of male and female plants, flower diameter (3- and 4-merous), and the dimensions of fruit and seeds were also significantly smaller for *A. gillii* when compared to *A. nigrum* (Table 1). Although mean staminate spike length was also significantly different between *A. gillii* (mean =15.3 mm) and *A. nigrum* (mean = 20.6 mm), mean staminate spike width was 2.9 mm regardless of species.

Our measurements of plant height for both mistletoe species were difficult to compare with those reportedly previously by Hawksworth and Wiens (1964, 1965, 1989, 1996) as they combined male and female plants in their analyses, and in lieu of reporting mean plant height for either species, they provided ranges and maximum measurements (Table 2). The maximum heights they reported for *A. gillii* (25 cm) and *A. nigrum* (45 cm) are similar to our maximum height for female plants of *A. gillii* (ca 28 cm) and for male plants of *A. nigrum* from central Mexico (ca. 53 cm; Table 1). Although the basal diameter for *A. gillii*, male and female plants combined, were approximately the same for our measurements (ca. 4.5 cm) as those reported previously by Hawksworth and Wiens (4.0 cm), the basal diameter of male and female plants of *A. nigrum* sampled in the present study were considerably larger (>7 mm) than that reported by Hawksworth and Wiens (5.0 mm). We also found that the dimensions of the third internode were generally larger for both species than those reported by Hawksworth and Wiens (see Tables 1 and 2 for comparison). Our measurements of 3-merous flowers for *A. gillii* and *A. nigrum*, however, were slightly smaller than those of Hawksworth and Wiens. Yet, to date and to the best of our knowledge, the diameters of 4-merous flowers, petal length and width as well as anther diameter of *A. gillii* have not been reported. Similarly, Mathiasen et al. (2012) as well as the present study remain the only reports to provide such measurement of 4-merous flowers, petal dimensions, and anther diameter for *A. nigrum*.

Our measurements of fruits were similar to those of Hawksworth and Wiens (1989, 1996) for the length of *A. nigrum* fruits, but our mean widths were larger (mean = 1.5; compare Tables 1 and 2). Our measurements indicated that *A. gillii* fruits are indeed larger (mean length = 5.8 mm, mean width = 3.6 mm) than what they reported; yet, seed length and width of *A. gillii* were similar in comparison to those found by Hawksworth and Wiens (compare Tables 1 and 2). As for *A. nigrum*, they reported larger seed lengths (3.5 mm) and smaller widths (1.3 mm) than our measurements (mean seed length = 3.1, mean seed width = 1.5 mm).

The only flower characteristic Hawksworth and Wiens reported for *A. nigrum* was the diameter of 3-merous flowers (3.5 mm), which was slightly larger than the average diameter for the 3-merous flowers we measured (mean = 3.2 mm). Our observations revealed that *A. nigrum* commonly produced 4-merous flowers as well; thus, we sampled and measured these flowers and found they averaged approximately 5 mm in diameter (mean = 4.8; Table 1). The mean diameter of 3- and 4-merous flowers of *A. nigrum* were also significantly larger than those of *A. gillii* (3-merous mean = 2.8 mm, 4-merous mean =3.6 mm). The petals of *A. nigrum* were relatively large in comparison to other dwarf mistletoes (Hawksworth & Wiens 1996; Mathiasen et al. 2012) as some lobes were >2 mm in length and nearly equally as large in width. In addition, examination of *A. nigrum* flowers also revealed that the adaxial surface of petals were dark red—a key phenotypic characteristic of this

TABLE 1. Morphological analyses (ANOVA) comparing *Arceuthobium gillii* and *A. nigrum*. Means followed by different capital letters in the same row were significantly different using a posteriori contrast comparisons (α = 0.05). Plant heights in cm and all other measurements in mm.

Character	ANOVA, Significance level	Mean (range) by Taxon	
		A. gillii	*A. nigrum*
Plant Height			
Male	$F_{1,228} = 138.00$, $P<0.0001$	12.3 A (7.3–21.6)	24.3 B (10.3–53.5)
Female	$F_{1,228} = 61.62$, $P<0.0001$	14.2 A (7.9–28.4)	19.6 B (9.3–37.2)
Basal Diameter			
Male	$F_{1,228} = 178.90$, $P<0.0001$	4.0 A (2.4–6.5)	7.0 B (4.4–12.5)
Female	$F_{1,228} = 338.97$, $P<0.0001$	5.3 A (2.9–8.5)	7.8 B (4.1–13.1)
Third Internode Length			
Male	$F_{1,228} = 175.50$, $P<0.0001$	10.6 A (6.1–16.7)	16.8 B (11.6–28.7)
Female	$F_{1,228} = 30.46$, $P<0.0001$	13.8 A (7.8–22.3)	16.5 B (11.8–31.8)
Third Internode Width			
Male	$F_{1,228} = 391.89$, $P<0.0001$	3.2 A (2.1–5.0)	4.9 B (4.0–7.8)
Female	$F_{1,228} = 102.49$, $P<0.0001$	4.2 A (2.6–6.6)	5.5 B (4.4–9.6)
Staminate Spike Length	$F_{1,398} = 100.84$, $P<0.0001$	15.3 A (6.9–25.6)	20.6 B (8.1–33.3)
Staminate Spike Width	$F_{1,398} = 1.51$, $P=0.2193$	2.9 A (2.1–3.5)	2.9 A (2.4–3.3)
Flower Diameter			
3-merous	$F_{1,198} = 103.71$, $P<0.0001$	2.8 A (2.1–3.5)	3.2 B (2.7–4.0)
4-merous	$F_{1,198} = 431.27$, $P<0.0001$	3.6 A (3.1–4.5)	4.8 B (3.6–5.4)
Petal length	$F_{1,398} = 236.72$, $P<0.0001$	1.4 A (1.0–1.8)	1.7 B (1.3–2.3)
Petal width	$F_{1,398} = 158.37$, $P<0.0001$	1.2 A (0.9–1.5)	1.4 B (0.8–1.9)
Anther Diameter	$F_{1,398} = 161.67$, $P<0.0001$	0.6 A (0.4–0.8)	0.8 B (0.5–1.1)
Anther Distance from Tip	$F_{1,398} = 124.10$, $P<0.0001$	0.4 A (0.2–0.7)	0.5 B (0.3–0.6)
Fruit Length	$F_{1,198} = 177.83$, $P<0.0001$	5.8 A (4.6–7.2)	6.9 B (5.2–8.8)
Fruit Width	$F_{1,198} = 118.42$, $P<0.0001$	3.6 A (2.8–4.4)	4.1 B (3.4–5.0)
Seed Length	$F_{1,198} = 97.60$, $P<0.0001$	2.8 A (2.0–3.3)	3.1 B (2.7–3.9)
Seed Width	$F_{1,198} = 55.82$, $P<0.0001$	1.4 A (1.1–1.6)	1.5 B (1.3–1.9)

TABLE 2. Morphological measurements for *Arceuthobium gillii* and *A. nigrum* reported by Hawksworth and Wiens (1996). Plant heights in cm and all other measurements in mm.

Character	*A. gillii*	*A. nigrum*
Plant Height[a]	8–15 [b] (Max. 25)	15–35 [b] (Max. 45)
Basal Diameter[a]	4.0 (2.5–8.0)	5.0 (3.0–8.0)
Mean Third Internode		
Length	10.7 (5.0–18.0)	10.8 (5.0–19.0)
Width	2.8 (2.0–4.5)	3.7 (2.5–6.0)
Plant Color	Greenish-brown	Dark brown-green, dark brown, black
Mean Flower Diameter[c]	3.2	3.5
(3-merous flowers)		
Anthesis	March–April	March–April, September–October
Seed Dispersal	October	September–October
Fruit		
Length	4.0–5.0 [b]	7.0 (6.0–9.0)
Width	2.0–3.0 [b]	3.5
Seed		
Length	3.1	3.5
Width	1.4	1.3

[a] Male and female plants combined.
[b] No mean was provided by Hawksworth and Wiens (1996), only a range.
[c] No other flower measurements (e.g., 4-merous, anther diameter, etc.) were reported by Hawksworth and Wiens (1996).

species throughout its geographic range (Fig. 2)—and remarkably different compared to the green petals of *A. gillii* (Fig. 3). These conspicuous, red-colored petals of *A. nigrum*, however, were never reported in the literature until recently by Mathiasen et al. (2012). The reason(s) for why this discriminatory and diagnostically useful



Fig. 2. Staminate plants of *Arceuthobium nigrum* in October in Durango, Mexico. Note the dark red flowers with 3 or 4 perianth lobes.

characteristic has gone unnoticed for nearly a half-century likely will remain unknown. However, petal color—a phenotypic characteristic unaffected by plant age—should be utilized by field botanists and forest health specialist alike for differentiating *A. nigrum* and *A. gillii*.

Phenology

According to our observations, flower phenology (period of anthesis) appeared also to be a delineating characteristic between *A. gillii* and *A. nigrum*. In southern Arizona and Chihuahua, Mexico, *A. gillii* flowered in early-March, or as late as May in some years, and terminated by late-April. In contrast, *A. nigrum* flowered only once annually between September and January. Hawksworth and Wiens (1989, 1996) reported two flowering periods—March–April and September–October—for *A. nigrum*; however, according to our records and review of herbarium specimens, a spring flowering period for this dwarf mistletoe has never been well documented. We, therefore, examined numerous populations of *A. nigrum* with male plants, including the type-locality in Durango, Mexico, in mid- to late-March 2003, 2005, and 2007, and again in early-April 2011; no open, staminate flowers were evident. Moreover, within the same localities and time periods, staminate flowers were not approaching maturity. Periodic fall surveys of the same *A. nigrum* populations in 1999–2010, however, revealed that this dwarf mistletoe flowered starting in mid-September and continued into November in Durango, Mexico, and peak flowering occurred in early-October. Similarly, anthesis began slightly later (mid-September) in central Mexico and continued into January; yet, the period of peak anthesis within central Mexico has remained uncertain. As with the advent of flowering, our observations indicated that *A. nigrum* began dispersing seed in early-September, peaked in mid-October, and continued into mid-November in Durango as well as



Fig. 3. Staminate plants of *Arceuthobum gillii* in late-March in southern Arizona. Note the green flowers with 3 perianth lobes.

central Mexico. Likewise, seed dispersal by *A. gillii* initiated in early September and peaked in early-October. These phenological observations for seed dispersal of *A. gillii* and *A. nigrum* were consistent with those previously reported (Hawksworth & Wiens 1996); however, they were not taxonomically informative between species.

Molecular Identification

Phylogenetic analyses of the ITS region for *A. gillii* and *A. nigrum* supported the morphological data, effectively delineating species as all plants diagnosed morphologically as *A. gillii* resolved to a monophyletic group (Fig. 4). The size of the ITS region (ITS1-5.8S-ITS2) for each sequence of *A. gillii* and *A. nigrum* was 600 bp while the total amplicon per taxon consisted of 623 bp with a partial sequence of the 18S (4 bp) and 26S (19 bp) located at the 5′- and 3′-end, respectively. The mean interspecific genetic distance (HKY+I) for both *A. gillii* (n = 10 pairwise comparisons) and *A. nigrum* (n = 21 pairwise comparisons) was 0.0018 substitutions/site. Similarly, mean nucleotide divergence (n) within species for *A. gillii* as well as *A. nigrum* was 1.0 nucleotide. Although readily distinguishable via DNA analysis, our results suggested that *A. nigrum* and *A. gillii* are more closely-related phylogenetically than previously demonstrated by Nickrent et al. (2004). The alignment used for ML and Bayesian analyses—including outgroup taxa *A. yecorense* and *A. oxacanum* as well as sequences of *A. gillii* and *A. nigrum* utilized in Nickrent et al. 2004—consisted of 625 total characters of which 531 were constant, 38 variable and parsimony-uninformative, and 56 parsimony-informative. The combined ML and Bayesian consensus tree strongly supported a single-clade (common ancestry; bootstrap value 100%, posterior probability 1.00) consisting of *A. nigrum* and *A. gillii*, with the latter resolving to a more distantly related, monophyletic subclade (bootstrap value 94%; posterior probability 1.00). The mean genetic distance (HKY+I; n = 49 pairwise

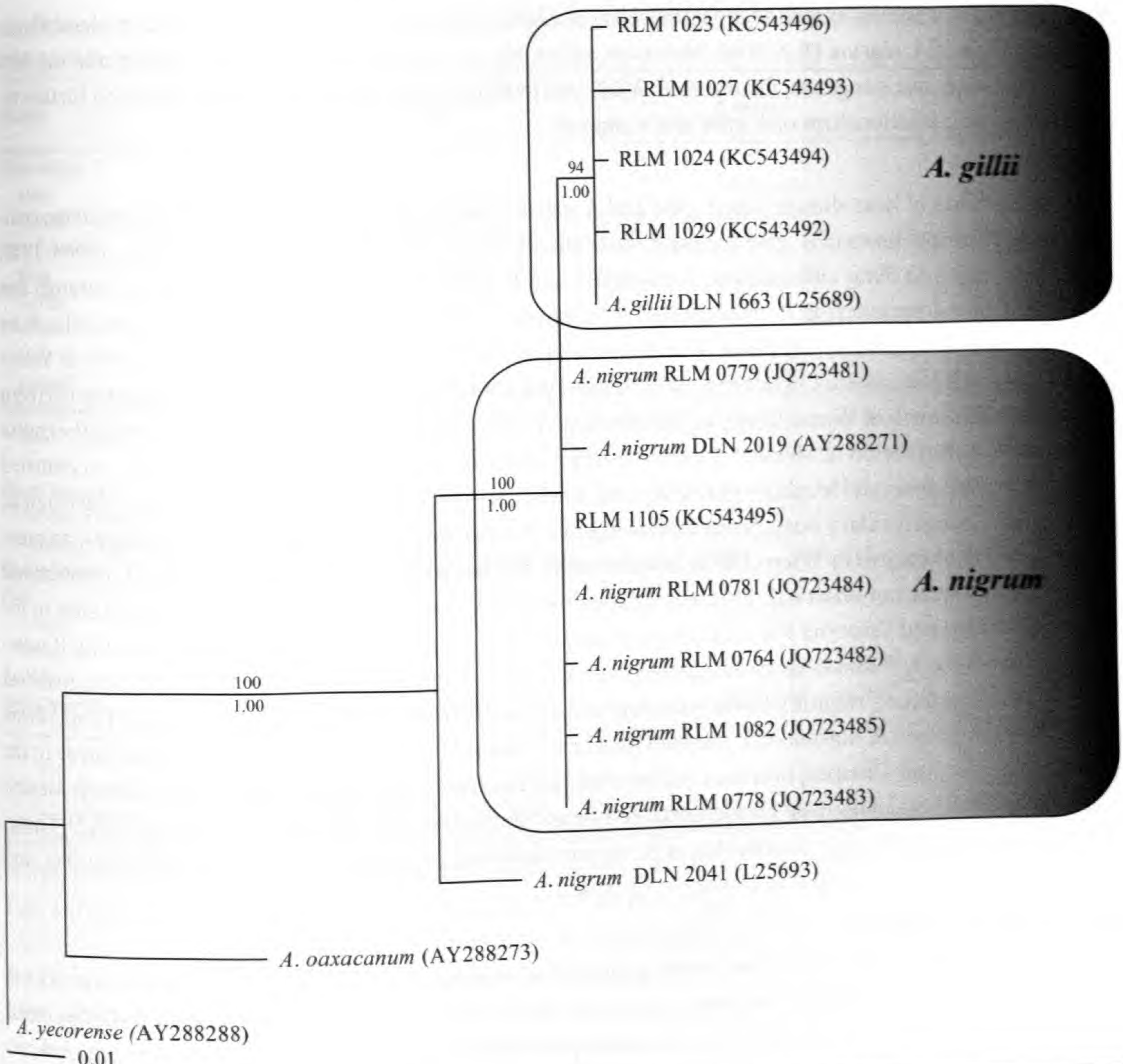


Fig. 4. Phylogram inferred from maximum likelihood (ML) analysis of nuclear ribosomal ITS sequences of *Arceuthobium gillii* and *A. nigrum*, and the outgroup taxa, *A. yecorense* and *A. oaxacanum* using a HKY+I model of sequence evolution. Numbers above branches indicate ML bootstrap values >70% (after 10^3 replicates), numbers below are Bayesian posterior probabilities > 0.95 (after 5.0×10^6 generations). Collector abbreviations RLM and DLN are for Robert L. Mathiasen and Daniel L. Nickrent, respectively, and precede assigned voucher numbers. GenBank accession numbers for each sequence are provided in parentheses (GenBank Accession no.). The geographical origin of *A. gillii* and *A. nigrum* collections/accessions are provided in Fig. 1 (bold).

comparisons) and mean nucleotide divergence (n) between *A. gillii* and *A. nigrum* was 0.0083 substitutions/site and 4.9 nucleotides, respectively. Forty-eight of the forty-nine (48/49) pairwise comparisons between *A. gillii* and *A. nigrum* shared 100% nucleotide identity (207/207 bases) in the ITS1 and were separated by approximately five or fewer substitutions across the 5.8S rRNA gene and ITS2—notably, consistent A/G nucleotide changes at positions 335, 421, 457, and 535. In contrast, the mean genetic distance (HKY+I; n = 4 pairwise comparisons) and nucleotide divergence between our newly generated ITS sequences of *A. gillii* and *A. nigrum* DLN 2041 sequence (GenBank L25693) utilized by Nickrent and colleagues (Fig.2 in Nickrent et al. 2004) was 0.0336 substitutions/site and 19.3 nucleotides, respectively. These genetic comparisons between *A. gillii* and that of *A. nigrum* DLN 2041 were nearly equal to those calculated in the present study when comparing the interspecific genetic variability of outgroup taxa, *A. yecorense* and *A. oaxacanum* (0.0331 substitutions/site, 19 nucleotide difference). The identity of *A. nigrum* DLN 2041 – species or potential hybrid—remains unclear and currently is being assessed (S.C. Kenaley & R.L. Mathiasen, unpubl. data). Therefore, the ITS sequences of *A.*

nigrum presented herein, as well as in Mathiasen et al. (2012), should be utilized for future species-level identification in lieu of *A. nigrum* DLN 2041. Moreover, additional phylogenetically informative molecular markers (e.g., single-copy nuclear genes; Duarte et al. 2010) and multigene analysis should be examined to further resolve the genetic relationships of *A. gillii* and *A. nigrum*.

Hosts

Our examination of host affinities for *A. gillii* and *A. nigrum* did not reveal any additional host-mistletoe combinations. Principal hosts of *A. gillii* included those already reported by Hawksworth and Wiens (1964, 1965, 1989, 1996) such as *Pinus chihuahuana*, *P. leiophylla*, and *P. lumholtzii*. *Arceuthobium nigrum* in Durango was most often found parasitizing *P. chihuahuana*, *P. leiophylla*, and *P. lumholtzii*, as well as *P. teocote* Schiede ex Schlechtendal & Chamisso; all pines were described previously as principal hosts (Hawksworth & Wiens 1996). Although *P. arizonica* Engelmann and *P. cooperi* Blanco are reported rare hosts of *A. nigrum* in northern Mexico (Hawksworth & Wiens 1996), we did not observe either host-mistletoe combination during the course of our work in that region of Mexico. However in central Mexico, *A. nigrum* was most frequently encountered on *P. teocote*, and at several localities in Hildago and Puebla, we often found *P. patula* Schiede ex Schlechtendal & Chamisso as a secondary host. *Arceuthobium nigrum* was also found on *P. pseudostrobus* Lindley – an occasional host (Hawksworth & Wiens 1996); however, other occasional hosts of *A. nigrum* such as *P. montezumae* A. B. Lambert, were not observed. This was disappointing as we purposefully examined forested sites in the States of Hidalgo and Veracruz where Hawksworth and Wiens purportedly found *A. nigrum* infecting *P. montezumae*, finding only *P. teocote* severely infected with *A. nigrum*. The status of *P. montezumae* as a principal host of *A. nigrum*, therefore, requires future examination and confirmation. Similarly, Hawksworth and Wiens (1989, 1996) reported *A. nigrum* on *P. lawsonii* Roezl ex Gordon & Glendinning and *P. oaxacana* Mirov in the States of Oaxaca and Chiapas; however, recent evidence has indicated that these pines in southern Mexico were infected with *A. hondurense* Hawksworth & Wiens (Mathiasen et al. 2003; Mathiasen et al. 2012). Therefore, the host and geographic distribution of *A. nigrum* likely does not include *P. lawsonii* or *P. oaxacana*, and this mistletoe does not extend into Oaxaca or Chiapas.

Geographic Distributions

Arceuthobium nigrum is primarily distributed geographically along the Central Volcanic Cordillera of central Mexico and north into Durango (Mathiasen et al. 2010, 2012). Although Hawksworth and Wiens (1989, 1996) reported that *A. gillii* and *A. nigrum* occur in the same mountain range near Tepehuanes, Durango, our observations and collections of plants from the same locations examined by Hawksworth in 1987 (Hawksworth & Wiens 1996), did not support this report. All of the populations we examined in the Tepehuanes area represented *A. nigrum*. The closest, and thus far, only population of *A. gillii* we found to date in Durango was near La Quebrada immediately south of the border with the State of Chihuahua (Fig. 1, location 7). Therefore, the common dwarf mistletoe on *P. leiophylla* and *P. chihuahuana* in Durango is *A. nigrum*, while *A. gillii* was the most frequent dwarf mistletoe on these pines in Chihuahua; we have not observed *A. nigrum* in Chihuahua thus far. Likewise, although *A. gillii* may be found to be sympatric with *A. nigrum* in Durango, we have not observed these mistletoes in the same pine stand or general location.

SUMMARY

The principal morphological and phenological differences distinguishing *A. gillii* from *A. nigrum* are summarized in Table 3. In general, the plants, flowers, and fruits of *A. gillii* are significantly smaller than those of *A. nigrum*, but their plant color variations and habit are very similar, making it difficult to discriminant them *in situ*. Although male plants of *A. gillii* are often green (Fig. 3), plants of both sexes are typically dark brown to greenish-brown (Fig. 2), and we have observed female plants of both species that appear almost black. Both species have relatively wide staminate spikes (ca. 3.0 mm) and demonstrate a striking sexual dimorphism: female plants being densely branched and compact and male plants are open and spreading (see Figs. 3.1 and 3.2 in Hawksworth & Wiens 1996). Furthermore, both species have strikingly glaucous fruits and they parasitize

TABLE 3. Principal morphological and phenological characteristics distinguishing *Arceuthobium gillii* and *A. nigrum*. Mean plant heights in cm and all other means in mm; maximum size measured in parentheses.

Character	*A. gillii*	*A. nigrum*
Plant Height		
Male	12.3 (21.6)	24.3 (53.5)
Female	14.2 (28.4)	19.6 (37.2)
Basal Diameter		
Male	4.0 (6.5)	7.0 (12.5)
Female	5.3 (8.5)	7.8 (13.1)
Third Internode Length		
Male	10.6 (16.7)	16.8 (28.7)
Female	13.8 (22.3)	16.5 (31.8)
Third Internode Width		
Male	3.2 (5.0)	4.9 (7.8)
Female	4.2 (6.6)	5.5 (9.6)
Flower Diameter		
3-merous flowers	2.8 (3.5)	3.2 (4.0)
4-merous flowers	3.6 (4.5)	4.8 (5.3)
Flower Color	Green or Green-yellow	Red
Fruit		
Length	5.8 (7.2)	6.9 (8.8)
Width	3.6 (4.4)	4.1 (5.0)
Anthesis	March–April	September–January
Seed Dispersal	October	September–October

the same hosts in northern Mexico. However, the mean sizes of all the morphological characters we examined, except staminate spike width, are significantly smaller for *A. gillii*, which has green, not red flowers (compare Figs. 2 and 3), and flowers in the spring and not the fall. Therefore, these taxa can be distinguished from each other by plant size, flower size and color, fruit size, and flowering period (Table 3) and should be treated as distinct species. Difficulties with identifying them in the field will be related primarily to their similar growth habit and plant color, so it is necessary to examine many plants from a population, determine plant, flower, and fruit dimensions for at least a small sample of these parameters and observe if male plants are flowering. If male plants are flowering, then the color of the flowers (green or red) and season (spring or fall) will positively identify if the population represents *A. gillii* or *A. nigrum* in northern Mexico where these species may co-occur. Based on our current knowledge of their distributions, *A. gillii* only occurs from southern Arizona and New Mexico south to far northern Durango, Mexico (Fig. 1), and *A. nigrum* occurs from central Durango near Tepehuanes south as far as Puebla, Tlaxcala, and Veracruz (Mathiasen et al. 2010, 2012). Therefore, it should be noted that most of the populations of *A. gillii* reported by Mathiasen et al. (2008) based on herbaria records from southern and central Durango probably represent populations of *A. nigrum*.

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THE GENUS *PLATANTHERA* (ORCHIDACEAE) IN MISSISSIPPI

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ABSTRACT

Platanthera Rich. is a genus in the Orchidaceae, subfamily Orchidoideae, tribe Orchideae, subtribe Orchidinae. There are approximately 200 species distributed across the Northern Hemisphere in boreal and temperate regions with centers of diversity in North America and East Asia. Of these taxa, 10 *Platanthera* species have been documented from Mississippi and are as follows: *P. ciliaris, P. clavellata, P. conspicua, P. cristata, P. flava, P. integra, P. integrilabia, P. lacera, P. nivea,* and *P. peramoena*. These inhabit a variety of wetland habitats, and some of them are indicators of unusual plant community types. Several of the species listed are of conservation concern. During July 2009 and July 2010 when plants were at anthesis, 14 trips were made to locate extant populations of *Platanthera* species, record habitat data, and visit the major herbaria in Mississippi. *Platanthera* specimens in the following herbaria were examined: University of Mississippi (MISS), Mississippi State University (MISSA), University of Southern Mississippi (USMS), Delta State University (DSC), Institute for Botanical Exploration (IBE), Mississippi Museum of Natural Science (MMNS), The Crosby Arboretum, and my personal collections. An artificial key and updated information on the distribution and habitats of the native Mississippi species are presented.

RESUMEN

Platanthera Rich. es un género de Orchidaceae, subfamilia Orchidoideae, tribu Orchideae, subtribu Orchidinae. Tiene unas 200 especies distribuidas por el hemisferio norte en las regiones boreales y templadas con centros de diversidad en Norte América y Este de Asia. De estos taxa, 10 especies de *Platanthera* han sido documentadas de Mississippi y son las siguientes: *P. ciliaris, P. clavellata, P. conspicua, P. cristata, P. flava, P. integra, P. integrilabia, P. lacera, P. nivea,* y *P. peramoena*. Viven en una variedad de hábitats húmedos, y algunas de ellas son Indicadores de tipos de comunidades poco frecuentes. Varias de las especies están en las listas de preocupación para la conservación. Durante julio de 2009 y julio de 2010 cuando las plantas estaban en antesis, se realizaron14 viajes para localizar poblaciones de especies de *Platanthera*, tomar datos del hábitat, y visitar los mayores herbarios de Mississippi. Se examinaron los especimenes de *Platanthera* en los siguientes herbarios: University of Mississippi (MISS), Mississippi State University (MISSA), University of Southern Mississippi (USMS), Delta State University (DSC), Institute for Botanical Exploration (IBE), Mississippi Museum of Natural Science (MMNS), The Crosby Arboretum, y mis colecciones personales. Se presenta una clave artificial e información puesta al día de la distribución y hábitats de las especies nativas de Mississippi.

INTRODUCTION

The Orchidaceae is one of the largest families of flowering plants (Correll 1978), with approximately 20,000 species; some estimates are as high as 35,000 species (Dressler 1981, 1993). The family is most speciose in the tropics, and the majority of taxa in this family exist as epiphytes. *Platanthera* Rich. is a genus of approximately 200 terrestrial species distributed primarily in the circumboreal and temperate zones in the Northern Hemisphere (Sheviak 2002). *Platanthera* species are particularly well-represented in North America and East Asia. Within the orchid family, *Platanthera* is classified in subfamily Orchidoideae, tribe Orchideae, subtribe Orchidinae. Species of *Platanthera* commonly have either tuberous or slender, fleshy roots, usually basal, lanceolate to oblanceolate leaves that become reduced to bracts farther up the inflorescence axes, and spicate or racemose inflorescences. Flower color ranges from white to greenish to shades of orange and purple. Lips and other petals of flowers are often fringed, hence the common name fringed orchids, although they may be entire. Nectar spurs are at flower bases. Among the species in the genus, pollination modes range from self-pollination in *P. clavellata* (Luer 1975), to insect pollination involving butterflies in *P. ciliaris*, and *P. integrilabia* (Zettler et al. 1996), butterflies, moths, and bees in *P. blephariglottis* (Smith & Snow 1976), day-flying sphinx moths in *P. lacera* (Yatskievych 1999) and *P. peramoena* (Hapeman & Inoue 1997), bumble bees in *P. cristata* and *P. integra*, and even mosquitoes in *P. flava* (Luer 1975). Reproductive biology greatly influences phylogenetic relationships within *Platanthera* (Bateman et al. 2009; Hapeman & Inoue1997).

Platanthera species native to Mississippi occur in a variety of wetland habitats, and some of them are indicators of unusual plant community types. Wetland types include dense cypress—hardwood swamp forests, spring branches and adjacent seepage slopes, bottomland hardwood/wet meadow ecotones, shrub and hillside *Sphagnum* bogs, bay swamps and pitcher plant savannas, mesic field/woodland ecotones, and open, upland pine woods with perched water tables. Disturbed habitats include highway medians, powerline rights-of-way, and gas pipelines running through wetlands. Regarding the latter, the periodic mowing/bush hogging likely promotes growth of fire-adapted *Platanthera* species needing high light intensities by removing encroaching trees and shrubs. These practices benefit the orchids if done at the right time of year, if herbicides are not sprayed, and if the ground is not mechanically disturbed. Several *Platanthera* species are of conservation concern and are tracked by the Mississippi Natural Heritage Program (2006); they are as follows: *P. conspicua* (= *P. blephariglottis* var. *conspicua*) (S2), *P. cristata* (S3), *P. integra* (S3), *P. integrilabia* (S1), *P. lacera* (S1S2), and *P. peramoena* (S2S3). Of these, two species have moderate to high priority global conservation rankings: *P. integra* (G3G4) and *P. integrilabia* (G2G3). This study was conducted because a floristic manual for Mississippi does not exist. Therefore, treatments of genera and families are needed as published journal articles at this time.

METHODS

During July, 2009 and July, 2010, when plants were at anthesis, 14 trips were made to locate extant populations of *Platanthera* species, record habitat data, and visit the major herbaria in Mississippi. These excursions were made to characterize specific habitat requirements of *Platanthera* species among the different physiographic regions in Mississippi. Herbarium visits were conducted to accurately determine county-by-county distribution among the physiographic regions in Mississippi and to make morphological measurements. *Platanthera* specimens in the following herbaria were examined: University of Mississippi (MISS), Mississippi State University (MISSA), University of Southern Mississippi (USMS), Delta State University (DSC), Institute for Botanical Exploration (IBE), Mississippi Museum of Natural Science (MMNS), The Crosby Arboretum, and my personal collections. Representative specimens examined are listed at the end of each treatment for the species in Missisippi. Material of *P. flava* deposited in MISS was on loan to Arkansas Tech at the time of this study. The following sources relevant for the flora of the southeastern United States were considered for synonymy in this paper: Clewell (1985), Godfrey and Wooten (1979), Luer (1972, 1975), Radford et al. (1968), Sheviak (2002), The International Plant Names Index (2012), Weakley (2012), Wofford (1989), and Wunderlin (1998).

RESULTS AND DISCUSSION

Ten species of *Platanthera* are known to occur in Mississippi, a state with ten physiographic regions (Lowe 1921; MARIS 2013; USGS 2013) (Fig. 1). They are as follows: *P. ciliaris*, *P. clavellata*, *P. conspicua*, *P. cristata*, *P. flava*, *P. integra*, *P. integrilabia*, *P. lacera*, *P. nivea*, and *P. peramoena*. Distribution of each taxon in Mississippi accompanies photographic images of each species and is based on herbarium vouchers examined and the USDA Plants Database (2013). Of the native *Platanthera* species, *P. ciliaris*, *P. clavellata*, and *P. flava* are the most widely distributed in the state. *Platanthera clavellata* and *P. flava* occur in practically every physiographic region, with the exception of the Black Belt and Jackson Prairies, and the Yazoo-Mississippi Delta, although *P. flava* is known from swamp and bottomland hardwood forests at the easternmost edge of the latter. While sometimes frequent in wetland areas with acidic soils in the Longleaf Pine Belt and Coastal Pine Meadows, *P. ciliaris* appears to be absent from circumneutral, calcareous, and heavy clay soils characteristic of the Pontotoc Ridge, Black Belt and Jackson Prairies, Loess Bluffs, and Yazoo-Mississippi Delta. Despite having a broad distribution in Mississippi similar to that of *P. ciliaris*, *P. cristata* is generally a rare species that inhabits shrub bogs, spring branch habitats with a partially open canopy, and moist to wet flatwoods.

Species of *Platanthera* primarily recorded from northern Mississippi include *P. integrilabia*, *P. lacera*, and *P. peramoena*. Both of the latter taxa sporadically occur. Most *P. lacera* populations are documented from moist meadows and woodland borders in the North Central Plateau, with outlying populations in the Tennessee River Hills and Longleaf Pine Belt. The majority of *P. peramoena* records are from bottomland hardwood forests and adjacent meadows in river and creek floodplains in the North Central Plateau and areas transitional to the

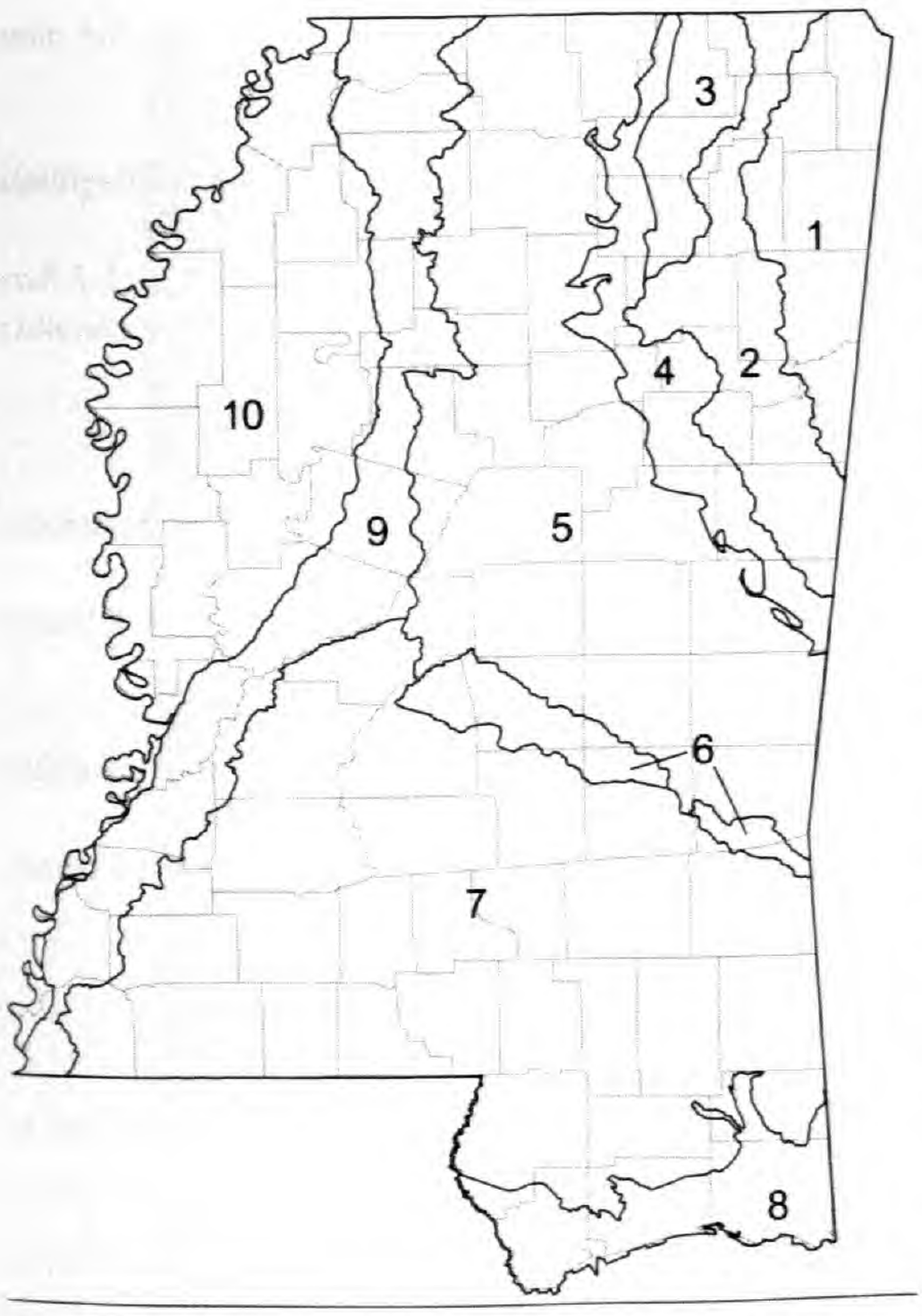


Fig. 1. Physiographic regions of Mississippi (adapted from MARIS 2013 and USGS 2013) (1 = Tennessee River Hills; 2 = Black Belt Prairie; 3 = Pontotoc Ridge; 4 = Interior Flatwoods; 5 = North Central Plateau; 6 = Jackson Prairie; 7 = Longleaf Pine Belt; 8 = Coastal Pine Meadows; 9 = Loess Bluffs; 10 = Yazoo-Mississippi Delta).

Loess Bluffs; populations are also supported in the Tennessee River Hills and Pontotoc Ridge in the northeastern corner of the state and in the Jackson Prairie and sites transitional to the Longleaf Pine Belt in central Mississippi, which are among the southernmost populations in the United States. *Platanthera integrilabia* is the rarest and most narrowly distributed of the fringed orchids in Mississippi and is only known from shaded wetland habitats of the Tennessee River Hills.

Platanthera conspicua, *P. integra*, and *P. nivea* are all characteristic of open pitcher plant bogs and savannas in the Longleaf Pine Belt and Coastal Pine Meadows of southern Mississippi. However, *P. nivea* is the only taxon not considered rare in the region; and it can even occur at sites transitional to sandhill habitats and infrequently in highly disturbed areas such as highway medians and rights-of-way. All three orchids typically inhabit fire-prone wetland sites with soils deficient in nitrogen in association with species such as the following: *Aletris lutea*, *Aristida beyrichiana*, *Carphephorus pseudo-liatris*, *Eriocaulon compressum*, *E. decangulare*, *Lachnanthes caroliniana*, *Lilium catesbaei*, *Lophiola aurea*, *Magnolia virginiana*, *Nyssa biflora*, *Persea palustris*, *Pinus elliottii*, *P. palustris*, *Stenanthium densum*, *Stokesia laevis*, *Taxodium ascendens*, *Tofieldia racemosa*, *Zigadenus glaberrimus*, and species of the genera *Cyperus*, *Dicanthelium*, *Drosera*, *Hypericum*, *Ludwigia*, *Pinguicula*, *Polygala*, *Rhexia*, *Rhynchospora*, *Sabatia*, *Sarracenia*, *Utricularia*. and *Xyris*. Associated orchids include: *Calopogon barbatus*, *C. multiflorus*, *C. pallidus*, *C. tuberosus*, *Cleistes bifaria*, *Pogonia ophioglossoides*, *Spiranthes longilabris*, and *S. praecox* (Morris 1989).

GENUS DESCRIPTION AND KEY TO THE SPECIES IN MISSISSIPPI

Platanthera Rich., FRINGED ORCHIDS

Glabrous erect perennial herbs with tuberous, fusiform, or occasionally fibrous roots; plants terrestrial in wetland habitats. Leaves simple, alternate, mostly basal, obovate-oblanceolate to linear-lanceolate, persistent, becoming reduced bracts toward the top of the plant. Inflorescence spicate to racemose. Flowers white or greenish to yellow, orange, or purple; sepals free, dorsal sepal erect or forming a hood over the column; lateral sepals spreading or recurved; petals free, simple or bipartite; lip lowermost (uppermost in *P. nivea*), entire, divided, or fringed, base of labellum modified into saccate to filiform nectar spur shorter than or longer than pedicel; column short; stigma with or without papillose processes; anther apical, 2-celled; pollinia 2, attached to partially to fully exposed viscid gland. Fruit a cylindric to ellipsoid capsule.

An artificial dichotomous key to the ten *Platanthera* species in Mississippi was constructed based on observations of both herbarium specimens and living plants in the field, and it is presented below.

KEY TO *PLATANTHERA* SPECIES IN MISSISSIPPI

1. Perianth white, greenish, or greenish-yellow (if greenish-yellow, then plants with up to four well-developed leaves along one-third to one-half the height of the inflorescence axis and often growing in shaded swamp forests).
   2. Lip conspicuously fringed, or lacerate.
      3. Perianth bright white; plants flowering from late July–September _____ **3. P. conspicua**
      3. Perianth greenish to dull greenish-white; plants flowering from May–June _____ **8. P. lacera**
   2. Lip without fringe, at most lobed or with small sharp-pointed teeth.

4. Lip uppermost in flowers (flowers not resupinate); plants of open savannas and shrub bogs _____ **9. P. nivea**
4. Lip lowermost in flowers (flowers at least partially to completely resupinate); plants typically of shaded swamps and bogs.
5. Nectar spur 4–5 cm long _____ **7. P. integrilabia**
5. Nectar spur up to 1 cm long.
6. Inflorescence with 10–40 loosely arranged flowers in an elongate spike _____ **5. P. flava**
6. Inflorescence with 3–15 flowers in a short raceme _____ **2. P. clavellata**

1. Perianth orange (to yellowish-orange) or purple (if yellowish-orange, then plants with usually 2–4 conspicuously *keeled* leaves along the basal or lower portion of the inflorescence axis and often growing in shrub bogs and open, wet savannas).
7. Perianth purple; plants of alluvial bottomland hardwoods, adjacent ditches, and meadows _____ **10. P. peramoena**
7. Perianth orange (to yellowish-orange).
8. Lip rounded, without fringe (apex with small irregular teeth) _____ **6. P. integra**
8. Lip ovate to oblong, conspicuously fringed.
9. Lip oblong, approximately 1 cm long, with ciliate fringe extending another 1 cm; nectar spur 2.0–3.5 cm long (obviously longer than pedicel) _____ **1. P. ciliaris**
9. Lip ovate, less than 5 mm long, with ciliate fringe extending up to another5 mm; nectar spur up to 1 cm long _____ **4. P. cristata**

1. Platanthera ciliaris (L.) Lindl. (**Figs. 2, 3, 13**). YELLOW FRINGED-ORCHID

Habenaria ciliaris (L.) R. Brown, *Orchis ciliaris* L.

Plant erect, often robust, to 100 cm tall. Leaves mostly basal, lanceolate, keeled, reduced and becoming bracts above, 15–30 cm long, 15–30 mm wide. Raceme densely or laxly flowered, bracteate, 5–17 cm long, 4.5–9 cm wide. Flowers 15–25 mm long, yellow-orange to orange; sepals ovate, 7–8 mm long, 6–7 mm wide, dorsal concave, lateral reflexed; petals linear, apex fringed, 5–6 mm long, 1–1.5 mm wide; lip oblong, 10–16 mm long, 6–8 mm wide, conspicuously ciliate-fringed; nectar spur slender, 2–3.5 cm long. Jul–mid-Aug(–early Sep). Open to shaded bogs and seepage slopes, wet fields and savannas, seepy roadcuts and adjacent ditches, and open, upland pine woods. Coastal Pine Meadows, Longleaf Pine Belt, North Central Plateau, Interior Flatwoods, and Tennessee River Hills. Infrequent to occasional (MA to Ont., MI, and IL, s to FL, w to e TX and OK).

Among *Platanthera* species in Mississippi, *P. ciliaris* has the most varied habitat preferences. In southern Mississippi, it frequently occurs in pitcher plant bogs and savannas with the same species listed above for *P. conspicua, P. integra*, and *P. nivea*. In Grenada County, located in the north central part of the state, *P. ciliaris* is encountered in boggy springheads with much *Sphagnum* and in adjacent open, sandy seepage areas with the following taxa: *Arnoglossum ovatum, Carex atlantica, C. crinita, C. laevivaginata, C. styloflexa, Chelone glabra, Doellingeria sericocarpoides, Drosera brevifolia, Eryngium integrifolium, Gentiana saponaria, Ilex verticillata, Impatiens capensis, Lobelia cardinalis, Lycopodiella appressa, Orontium aquaticum, Osmunda cinnamomea, O. regalis, Oxypolis rigidior, Persicaria sagittata, Photinia pyrifolia, Rhexia virginica, Rhododendron canescens, Rhynchospora glomerata, Solidago patula, Sphenopholis pensylvanica, Symphyotrichum puniceum, Vaccinium corymbosum, Viburnum nudum, Woodwardia areolata*, and *Xyris torta* (Morris 1988). Companion orchid species include *Platanthera clavellata* and *Spiranthes cernuua*.

Representative specimens examined: **U.S.A. MISSISSIPPI. Attala Co.:** ca. 3.5 mi SE of intersection of hwy 35 and Natchez Trace Parkway, 32.98278, -89.5583, moist seepage area along pipeline right-of-way, 15 Jul 1991, *Wieland 6550* (MMNS). **Grenada Co.:** ca. 2.5 mi NNW of Gore Springs, (T22N, R6E, S12, S2), in springhead bog with much *Sphagnum*, 29 Jul 1985, *Morris 405* (mwm, pers. herb. of Michael Wayne Morris). **Hancock Co:** Hillside Bog Natural Area of the Crosby Arboretum, ecotone of open bog and *Magnolia virginiana—Taxodium ascendens—Nyssa biflora*, 4 Aug 1986, *Morris 2423* (herbarium of the Crosby Arboretum). **Jackson Co.:** ca. 2.0 mi N of Escatawpa on E side of Sarracenia Rd., Mississippi Sandhill Crane National Wildlife Refuge, savanna, frequent, 8 Sept 1983, *Norquist 1396* (MMNS). **Monroe Co.:** ca. 1.5 mi N of Hately Detroit Rd., old mining site, with *Pogonia ophioglossoides, Platanthera clavellata, Sphagnum, Fuirena squarrosa, Carex atlantica*, 23 Jul 1993, *MacDonald 6459* (MMNS). **Winston Co.:** ca. 2.9 mi N of junction of Hwy, 25 and Hwy. 19, roadside, 2 Aug 1997, *MacDonald 10899* (MMNS).

2. Platanthera clavellata (Michx.) Luer (**Figs. 4, 5, 10**). SMALL GREEN WOOD-ORCHID

Habenaria clavellata (Michx.) Spreng., *Orchis clavellata* Michx.

Plant erect, small, to 40 cm tall. Leaves mostly basal, usually one, sometimes two, oblanceolate, reduced and becoming widely spaced bracts above, 8.5–14.5 cm long, 12–28 mm wide. Raceme few- to many-flowered,



Fig. 2. *Platanthera ciliaris*, Jackson County, Mississippi.



Fig. 3. Known distribution of *Platanthera ciliaris* in Mississippi.

2.5–6 cm long, 2–2.8 cm wide. Flowers 4–6 mm long, yellowish white to greenish; sepals ovate, obtuse, 4 mm long, 2.5 mm wide; petals obovate, 5 mm long, 2 mm wide; lip oblong, truncate, apex tridentate, 5–6 mm long, 2.5–3 mm wide; nectar spur slender and broadest distally, 9–14 mm long. Late Jun–early Aug. Shaded, mossy stream banks, springs, bogs, seepage slopes in woods, and swamp forests. Coastal Pine Meadows, Longleaf Pine Belt, North Central Plateau, Loess Bluffs, Interior Flatwoods, Pontotoc Ridge, and Tennessee River Hills. Infrequent to occasional (sometimes locally frequent) (Nfld. to Ont. and MN, s to n FL, w to se OK and e TX).

One of the most common orchid species in Mississippi, *P. clavellata* frequents shaded wetland sites, often rooted in *Sphagnum* in bay swamps and along spring branches in rich deciduous hardwood forests. Many of the same species associated with *P. ciliaris* in northern Mississippi also occur with *P. clavellata*. Additional taxa include: *Chasmanthium laxum*, *Itea virginica*, *Lilium superbum*, *Magnolia virginiana*, *Nyssa biflora*, *Oxydendrum arboreum*, *Persea palustris*, *Thelypteris noveboracensis*, *Toxicodendron vernix*, *Veratrum virginicum*, and *Viburnum dentatum*. Associ-



Fig. 4. *Platanthera clavellata*, Grenada County, Mississippi.



Fig. 5. Known distribution of *Platanthera clavellata* in Mississippi.

ated orchid species are *Isotria verticillata, Platanthera ciliaris, P. cristata,* and *Spiranthes cernuua.*

Representative specimens examined: **U.S.A. MISSISSIPPI. Choctaw Co.:** ca. 2.5 mi S of Tomnolen, deciduous woods around springhead and creek, 20 Jul 1978, *Gordon* 539 (MMNS). **Grenada Co.:** ca. 2.5 mi NNW of Gore Springs, (T22N, R6E, S12, S2), in springhead bog with much *Sphagnum,* associated with *Lobelia cardinalis, Chelone glabra, Eryngium integrifolium, Impatiens capensis, Gentiana saponaria, Platanthera ciliaris, Spiranthes cernuua,* 12 Jul 1985, *Morris 400* (mwm, pers. herb. of Michael Wayne Morris); ca. 3 mi SE of Gore Springs, (T21N, R7E, S5), in a springhead bog with *Arnoglossum ovatum, Oxypolis rigidior, Solidago patula,* 23 Jul 1986, *Morris* 2356 (IBE). **Itawamba Co.:** ca. 1 mi N of Fulton, (T9S, R8E, S24, NE4), seepage swamp, with *Magnolia virginiana, Toxicodendron vernix,* 3 Aug 1983, *Gordon 2921* (MMNS). **Jasper Co.:** 31.9572, -89.2675, (T1N, R13W, S3, SW4), black gum/sweetbay drain, 7 Oct. 2003, *Sullivan 03-265* (MMNS). **Marion Co.:** frequent in seepage areas in ravines, beech-magnolia forest, Red Bluff, E side of Pearl River, 27 Jul 1978, *Rogers 45328* (MMNS). **Scott Co.:** Roosevelt State Park, 32.3144, -89.6752, sphagnum drain NW of lake, piney woods with gum-bay drains, 29 Jul 2004, *Sullivan 04-680* (MMNS).

3. Platanthera conspicua (Nash) P.M. Brown (**Figs. 6, 7**). LARGE WHITE FRINGED-ORCHID

Habenaria conspicua Nash, *Platanthera blephariglottis* (Willd.) Lindl. var. *conspicua* (Nash) Luer

Plant erect, robust, to 100 cm tall. Leaves mostly basal, ovate-lanceolate to linear-lanceolate, reduced and becoming bracts above, 15–21 cm long, 7–23 mm wide. Raceme densely or laxly flowered, bracteate, 7–14 cm long, 4–8 cm wide. Flowers 15–25 mm long, white; sepals ovate, 5–11 mm long, 4–9 mm wide, dorsal concave, lateral reflexed; petals linear, apex fringed, 5–8 mm long, 1.5–3 mm wide; lip ovate, 9–11 mm long, 2–5 mm wide, conspicuously fringed; nectar spur slender, 3–4 cm long. Late July–mid-September. In wet *Sphagnum* bogs and savannas. Coastal Pine Meadows and Longleaf Pine Belt. Rare (NC, s to FL, w to MS and e TX; largely coastal). *Platanthera conspicua* in MS toward SW periphery of range. Global and state conservation status: **G4G5; S2.**



Fig. 6. *Platanthera conspicua*, Perry County, Mississippi.



Fig. 7. Known distribution of *Platanthera conspicua* in Mississippi.

Plants of *P. conspicua* appear to favor the ecotone between herb/sedge bogs and *Magnolia virginiana—Nyssa biflora—Persea palustris—Taxodium ascendens* communities along drainages through sites supporting this species. A population in Perry County within the DeSoto National Forest is associated with *Peltandra sagittifolia*.

Representative specimens examined: **U.S.A. MISSISSIPPI. George Co.:** ca. 5 mi S of Agricola School, 30.74583333, -88.49861111, large quaking bog in Dorovan-Johnston series soil, with Sphagnum, grasses, sedges dominating, 27 Aug 1981, *Gordon 2706* (MMNS). **Jackson Co.:** ca. 4 mi NE of Pecan, 30.50555556, -88.40611111, disturbed hillside bog on edge of borrow pit, 25 Aug 1981, *Gordon 2694* (MMNS);ca. 1 mi ENE of Pecan, 30.45167, -88.4025, pine savanna on edge of cypress drain and bayhead, 25 Aug 1981, *Gordon 2671* (MMNS).

4. Platanthera cristata (Michx.) Lindl. (**Figs. 8, 9**). CRESTED FRINGED-ORCHID

Habenaria cristata (Michx.) R. Brown, *Orchis cristata* Michx., *Platanthera pallida* P.M. Brown.

Plant erect, to 60 cm tall. Leaves mostly basal, lanceolate, keeled, reduced and becoming bracts above, 12.5–25 cm long, 16–26 mm wide. Raceme cylindrical, densely (to loosely) flowered, bracteate, 2.5–9.5 cm long, 2.5–3.2 cm wide. Flowers 5–7 mm long, bright orange; dorsal sepal elliptic, concave, 4.5 mm long, 3.5 mm wide, lateral sepals orbicular, oblique, 4 mm long, 4 mm wide; petals obovate, apex broadly ciliate, 3 mm long, 1.5 mm wide; lip ovate, 4 mm long, conspicuously ciliate-fringed; nectar spur slender, 4–6(–10) mm long. Mid-Jul–mid-(late-)Aug. Open to shaded bogs and seepage slopes, springs, mossy stream banks, and wet areas along gas pipelines and powerline rights-of-way. Coastal Pine Meadows, Longleaf Pine Belt, North Central Plateau, Interior Flatwoods, and Tennessee River Hills. Rare to infrequent (MA s to c FL, w to AR and e TX; c TN). State conservation status: **S3.**



Fig. 8. *Platanthera cristata*, Rankin County, Mississippi.



Fig. 9. Known distribution of *Platanthera cristata* in Mississippi.

Habitats supporting *P. cristata* populations in Mississippi are mostly intermediate between more open sites in which *P. ciliaris* is most often found and more shaded sites in which *P. clavellata* occurs; however, *P. cristata* may occur with both fringed orchid species (Morris 1997). In northern and central Mississippi, *P. cristata* often occupies the ecotone between shaded spring branches and more open grass/sedge meadows at the edges of beaver ponds or along powerline rights-of-way running through bay swamp communities. Here, associated species include many of those listed for *P. ciliaris*, along with the following taxa: *Aletris aurea, Bartonia paniculata, Carex glaucescens, Carex leptalea, Cyperus haspan, Drosera capillaris, Elephantopus nudatus, Eupatoriadelphus fistulosus, Fuirena squarrosa, Hydrolea ovata, Hypericum crux-andreae, Hypericum gymnanthum, Lechea minor, Lespedeza capitata, Liatris spicata, Ludwigia hirtella, Lycopodiella alopecuroides, Lyonia ligustrina, Mitreola petiolata, Pluchea foetida, Polygala cruciata, P. mariana, Rhynchospora inexpansa*, and *Sophronanthe pilosa*. In southern Mississippi, it is present at bases of seepage slopes and along springs and streams where there is usually a partially open canopy in the bay swamp community, among other places. In addition to common bay swamp species already mentioned, the following are known to occur with south Mississippi *P. cristata* populations: *Apteria aphylla, Clethra alnifolia, Cliftonia monophylla, Cyrilla racemiflora, Drosera intermedia, Dulichium arundinaceum, Hypericum galioides, Ilex amelanchier, Ilex myrtifolia, Illicium floridanum, Kalmia latifolia, Leucothoe axillaris, L. racemosa, Ludwigia pilosa, Pogonia ophioglossoides, Rhododendron viscosum, Smilax laurifolia*, and *Sparganium americanum*.



Fig. 10. Swamp forest habitat supporting populations of *Platanthera clavellata* and *Platanthera flava*, Grenada County, Mississippi.

Representative specimens examined: **U.S.A. MISSISSIPPI. George Co.:** ca 5 mi S of Agricola, quaking bog in Dorovan-Johnston Series soil, 23 Jul 1981, *Gordon 2567* (MMNS). **Grenada Co.:** ca. 4.5 mi SSE of Gore Springs, (T21N, R7E, S8, E2), in bog at edge of beaver pond, 31 Jul 1986, *Morris 2405* (IBE, mwm). **Jackson Co.:** Red Creek Mitigation Bank E of Hwy 57, 30.7092, -88.7222, roadside ditch in pine plantation uplands, 25 Jul 2006, *Sullivan 06-1422* (MMNS). **Monroe Co.:** ca. 5 mi N of Aberdeen, (T14S, R7E, S3, SE4), near edge of woods by Acker Lake, 1 Aug 1995, *MacDonald 9023* (MMNS). **Oktibbeha Co.:** ca. 0.5 mi N of Cedar Grove Rd., off Hwy 25, Noxubee National Wildlife Refuge, flatwoods, 19 Jul 1994, *Liedolf 0526* (MMNS). **Perry Co.:** DeSoto National Forest, Leaf River Wildlife Management Area, bay swamp, scarce in peaty muck along stream, 19 Jul 1994, *Wyrick 94-120* (MMNS). **Rankin Co.:** ca 16 mi SE of Brandon, in moist to wet flatwoods along a gas pipeline and adjacent to dry-mesic woods with scattered longleaf pines, co-occurring with *P. ciliaris*, 31 Jul 1995, *Morris 4384* (IBE).

5. **Platanthera flava** (L.) Lindl. (**Figs. 10–12**). SOUTHERN REIN-ORCHID

Habenaria flava (L.) R. Brown, *Orchis flava* L., *Perularia scutellata* (Nutt.) Small

Plant erect, leafy, to 50 cm tall. Leaves mostly basal, lanceolate, reduced and becoming bracts above, 9–17 cm long, 20–50 mm wide. Spike loosely flowered, bracteate, 7–19.5 cm long, 10–18 mm wide. Flowers 2.5–6 mm long, yellow-green; dorsal sepal ovate, concave, 2–4 mm long, 2–3 mm wide, lateral sepals ovate, oblique, 2–4 mm long, 2–3 mm wide; petals ovate, concave, 2–4 mm long, 2–3 mm wide; lip ovate, rounded, the base with a triangular lobe on each side, 5 mm long, 4 mm wide; nectar spur 4–8 mm long, 1 mm wide. Jul–early Oct. Mucky depressions along streams in shaded forests, swampy hardwoods at bases of bluffs, and along braided streams in dense cypress—hardwood swamp forests. Coastal Pine Meadows, Longleaf Pine Belt, North Central Plateau, Loess Bluff/Yazoo-Mississippi Delta transition areas, Interior Flatwoods, Pontotoc Ridge, and Tennessee River Hills. Infrequent (NS to Ont. and MN, s to c FL, w to e TX and IA). *Platanthera flava* (L.) Lindl. var. *flava* in MS near central part of range.

Mosquitoes, the pollinating agents of *P. flava* (Luer 1975), abound where this orchid grows. Plants tend to grow along the banks of braided streams in colluvial swamp forests, in old stream channels filled with muck, and at the bases of large bald cypress trees. Although widespread in Mississippi, *P. flava* is not common. Associated species in a swamp forest located in the Loess Bluffs in close proximity to the Yazoo-Mississippi Delta in Grenada County are: *Acer rubrum, Asimina triloba, Carex bromoides, Carpinus caroliniana, Cicuta maculata, Cornus foemina, Dasistoma macrophyllum, Dryopteris x australis, Impatiens capensis, Itea virginica, Lindera ben-*



Fig. 11. *Platanthera flava*, Lafayette County, Mississippi.



Fig. 12. Known distribution of *Platanthera flava* in Mississippi.

zoin, Lobelia cardinalis, Osmunda regalis, Platanthera clavellata, Populus heterophylla, Rhynchospora miliacea, Rudbeckia fulgida, Sabal minor, Saururus cernuus, Solidago patula, Taxodium distichum, and *Thelypteris palustris.*

Representative specimens examined: **U.S.A. MISSISSIPPI. Benton Co.:** swampy woods near Indian Creek, 10 Aug 1976, *Browne 76D3.17* (MMNS). **Chickasaw Co.:** along Chuquatonche Creek, frequent in wet soil in bottom of old stream in deciduous forest below bluff, 31 Jul 1980, *Gordon 2074* (MMNS). **Grenada Co.:** ca. 3 mi NW of Holcomb, (T22N, R3E, S7, W2), near small stream in boggy woods, 8 Jul 1986, *Morris 2262* (IBE, MMNS, mwm). **Panola Co.:** ca. 6 mi SSW of Batesville along Panola-Quitman Floodway, bottomland hardwood forest, 4 Aug 1980, *Pullen Pa2-88* (MMNS). **Pearl River Co.:** 30.925, -89.878, Hillsdale Rd. near railroad crossing, bay drain, 22 Sept 2004, *Sullivan 04-754* (MMNS). **Tishomingo Co.:** J.P. Coleman State Park, woods and borders along Pickwick Lake, 5 Oct 1978, *Rogers 46208* (MMNS).

6. Platanthera integra (Nutt.) A. Gray ex L.C. Beck (**Figs. 13–15**). YELLOW FRINGELESS-ORCHID

Habenaria integra (Nutt.) Spreng., *Orchis integra* Nutt.

Plant erect, to 65 cm tall. Leaves mostly basal, lanceolate, keeled, conduplicate, reduced and becoming bracts above, 5.5–19 cm long, 8–17 mm wide. Raceme cylindrical, densely flowered, bracteate, 3–6 cm long, 2.5–3 cm wide. Flowers 5–7 mm long, 5–6 mm wide, yellow-orange; sepals obovate to orbicular, dorsal sepal 4 mm long, 3 mm wide, concave, lateral sepals 5 mm long, 4 mm wide, oblique; petals elliptic, 4 mm long, 1.5 mm wide; lip oblong, rounded, 4–6 mm long, 3–4 mm wide, crenulate to rarely entire; nectar spur 4–6 mm long. Jul–mid-Sep. Open, wet savannas and hillside bogs. Coastal Pine Meadows and Longleaf Pine Belt. Rare (NJ and DE, NC to n FL, w to e TX; TN; primarily coastal). Global and state conservation status: **G3G4; S3.**



Fig. 13. Savanna habitat supporting populations of *Platanthera ciliaris* and *Platanthera integra*, Crosby Arboretum, Hancock County, Mississippi.

Platanthera integra is found in pine savannas, pitcher plant bogs, and just upslope from "quaking bogs" in the vicinity of natural ponds with floating mats of vegetation. Frequent fires, historically caused by lightning strikes, are critical to maintaining the open, park-like nature of suitable *P. integra* habitat. Vascular plant species growing in association with *P. integra* are those listed above that are also known to grow with *P. conspicua* and *P. nivea*.

Representative specimens examined: **U.S.A. MISSISSIPPI. George Co.:** ca. 5 mi S of Agricola School, 30.7458, -88.4986, large quaking bog in Dorovan-Johnston Series soil, 27 Aug 1981, *Gordon 2716* (MMNS). **Hancock Co.:** Hillside Bog Natural Area of the Crosby Arboretum, pitcher plant bog, locally abundant, 4 Aug 1986, *Morris 2422* (DSC, herbarium Crosby Arboretum). **Harrison Co.:** ca. 2 mi S of Landon, (T7S, R12W, S12), large quaking bog with floating mats of vegetation, 11 Aug 1981, *Gordon 2657* (MMNS). **Jackson Co.:** ca. 2.6 mi SSW of Larue, (T5S, R9W, S23, SW4), DeSoto National Forest, pine savanna and bog, 11 Aug 1981, *Gordon 2649* (MMNS).

7. **Platanthera integrilabia** (Correll) Luer (**Figs. 16, 17**). MONKEY-FACE

Habenaria blephariglottis (Willd.) Hook. var. *integrilabia* Correll, *H. correlliana* Cronq.

Plant erect, to 60 cm tall. Leaves mostly basal, elliptic to lanceolate, keeled, reduced and becoming bracts above, 20–23 cm long, 40–42 mm wide. Raceme loosely few- to many-flowered, bracteate, 6.5–7.5 cm long, 4–6.5 cm wide. Flowers 10–12 mm long, 9–10 mm wide, white; sepals suborbicular to broadly ovate, dorsal sepal 8 mm long, 6 mm wide, concave, lateral sepals 9 mm long, 7 mm wide, reflexed; petals oblong, entire, 7 mm long, 2.5 mm wide; lip spatulate-lanceolate, 13 mm long, 3 mm wide, margin serrulate; nectar spur slender, curved, 3.5–4 cm long. Aug. Shaded spring branches and bogs in dense woods. Tennessee River Hills. Rare (sw NC to KY, s to n GA, AL, and ne MS). *Platanthera integrilabia* at SW periphery of range in MS. Global and state conservation status: **G2G3, S1.**



Fig. 14. *Platanthera integra*, Hancock County, Mississippi.



Fig. 15. Known distribution of *Platanthera integra* in Mississippi.

Extant populations of *P. integrilabia* in Mississippi are in Itawamba and Tishomingo counties. Plants occur with *Acer rubrum, Athyrium filix-femina, Carex leptalea, Liriodendron tulipifera, Magnolia virginiana, Oxydendrum arboreum, Photinia pyrifolia, Platanthera cristata, Prunus serotina, Rhododendron arborescens, Woodwardia areolata,* and *Xanthorhiza simplicissima* near the headwaters of a stream at a Tishomingo County site. Several historical Mississippi populations from elsewhere in the Tennessee River Hills have been extirpated due to flooding associated with the construction of dams to form lakes for erosion control and recreational purposes.

Representative specimens examined: **U.S.A. MISSISSIPPI. Tishomingo Co.:** ca. 1.5 mi NE of Paden, 34.6688, -88.2433, seepage bogs draining into Pollard Mill Branch, 23 Aug 1995, *Herring s.n.* (MMNS).

8. Platanthera lacera (Michx.) G. Don (**Figs. 18, 19**). RAGGED FRINGED-ORCHID, GREEN FRINGED-ORCHID

Habenaria lacera (Michx.) R. Brown, *Orchis lacera* Michx.

Plant erect, to 50 cm tall. Leaves mostly basal, elliptic to lanceolate, keeled, reduced and becoming bracts above, 6.5–11 cm long, 12–15 mm wide. Raceme mostly laxly flowered, bracteate, 7.5–14 cm long, 4–4.5 cm wide. Flowers 17–19 mm long, 7–10 mm wide, greenish; sepals ovate to oblong, dorsal sepal 4–7 mm long, 3–5 mm wide, lateral sepals 4–8 mm long, 3–4 mm wide, spreading; petals linear-oblong, sometimes denticulate, 5–8 mm long, 2 mm wide; lip tripartite and further divided into filiform segments, 10–12(–17) mm; nectar spur slender,



Fig. 16. *Platanthera integrilabia*, originally from Tishomingo County, Mississippi; in garden in Hinds County, Mississippi.



Fig. 17. Known distribution of *Platanthera integrilabia* in Mississippi.

curved, club-shaped, 1.2 cm long. Mid-May–Jun. Mesic field/woodland ecotones, hardwoods along creeks, and roadside ditches. Longleaf Pine Belt, North Central Plateau, and Tennessee River Hills. Rare (Nfld. to Man., s to c GA, AL, w to ne TX, e OK, and e KS). *Platanthera lacera* at southern periphery of range in MS. State conservation status: **S1S2.**

In Grenada County, *P. lacera* occurs in a rich deciduous woods/pasture ecotone with the following vascular plant species: *Acer rubrum, Aesculus pavia, Arisaema dracontium, Carpinus caroliniana, Carya cordiformis, Corylus americana, Juglans nigra, Liriodendron tulipifera, Lobelia cardinalis, Ostrya virginiana, Prunus serotina, Quercus rubra,* and *Thalictrum pubescens*. The orchid species *Listera australis, Spiranthes lacera* var. *gracilis*, and *S. ovalis* are in close proximity. In Mississippi, it is difficult to search for new populations of *P. lacera*, due to the fact that it is hard to characterize a consistent habitat type for the species.

Representative specimens examined: **U.S.A. MISSISSIPPI. Grenada Co.:** ca. 2.5 mi NNW of Gore Springs, (T22N, R6E, S12, W2), at rich deciduous woods/pasture ecotone, rare, 19 May 1986, *Morris 996* (mwm, pers. herb. of Michael Wayne Morris); (T21N, R6E, S11, NW4), Camp McCain, low bottomland hardwoods, rare, 31 May 1996, *MacDonald 9485* (MMNS). **Webster Co.:** 33.4672, -89.4633, roadside ditch, 1 Jun 1980, *Herring s.n.* (MMNS).

9. *Platanthera nivea* (Nutt.) Luer (**Figs. 20, 21**). SNOWY ORCHID

Habenaria nivea (Nutt.) Spreng., *Orchis nivea* Nutt.

Plant erect, to 70 cm tall. Leaves mostly basal, lanceolate, keeled, conduplicate, reduced and becoming bracts above, 15–26 cm long, 10–15 mm wide. Raceme cylindrical, densely flowered, bracteate, 6–7 cm long, 2–2.5 cm wide. Flowers non-resupinate (lip uppermost), 8 mm long, 5 mm wide, pure white; sepals ovate to oblong, middle sepal 5 mm long, 3 mm wide, lateral sepals 6 mm long, 2.5 mm wide; petals oblong, dilated at base, 5 mm long, 2 mm wide; lip linear-elliptic, 6 mm long, 2 mm wide; nectar spur slender, straight, 14–15 mm long. Jun–Jul(–early Aug). Open savannas, shrub bogs, and rarely highway medians and rights-of-way. Coastal Pine Meadows, Longleaf Pine Belt, historically and very



Fig. 18. *Platanthera lacera*, herbarium specimen in Riker Mount from Grenada County, Mississippi.



Fig. 19. Known distribution of *Platanthera lacera* in Mississippi.

rarely from the southern North Central Plateau. Infrequent (NJ and DE, NC to FL, w to se TX and s AR; largely coastal).

Unusual among the genus in the southeastern United States, *P. nivea* positions its flowers so that the lip is uppermost; all other *Platanthera* species in Mississippi have the lip, or labellum, in the lowermost position on each flower. This species needs open, park-like habitats maintained by low-intensity fires at regular intervals. In terms of soil moisture, *P. nivea* can occur in the transition areas between moist to wet savannas and the surrounding more xeric sandhill habitats also supporting *Pinus palustris*, *Ilex glabra*, and *Serenoa repens*.

Representative specimens examined: **U.S.A. MISSISSIPPI. Hancock Co.:** ca. 8 mi E of Picayune along Hwy 43, sphagnum bog with *Drosera*, *Xyris*, *Rhynchospora*, *Eriocaulon*, *Sabatia*, *Taxodium*, 7 Aug 1980, *Gordon 2141* (MMNS). **Jackson Co.:** ca. 1 mi W of MS/AL state line on S side of US Hwy. 90, (T7S, R4W, S5), savanna, Bayboro soils, infrequent in drain, 7 Jun 1983, *Norquist 1095* (MMNS); ca. 3 mi SE of Ocean Springs, Sandhill Crane National Wildlife Refuge, (T7S, R5W, S31), savanna, 8 Jul 1983, *Norquist 1213* (MMNS). **Stone Co.:** ca. 14 mi E of Perkinston, University Forest Lands Headquarters, pinelands and pitcher plant bogs, 28 Jun 1968, *Temple 9529* (MMNS).

10. Platanthera peramoena A. Gray (**Figs. 22, 23**). PURPLE FRINGELESS-ORCHID, PRIDE-OF-THE-PEAK

Habenaria peramoena A. Gray, *Platanthera fissa* Lindl.

Plant erect, to 100 cm tall. Leaves distributed along basal and middle portions of inflorescence axis, elliptic to lanceolate, keeled, reduced and becoming bracts above, 8.5–18 cm long, 12–33 mm wide. Raceme densely flowered, bracteate, 6.5–20 cm long, 5.5–7.5 cm wide. Flowers 20 mm long, 12 mm wide, violet-purple; sepals elliptic, dorsal sepal 5–9 mm long, 4–7 mm wide, lateral sepals 6–9 mm long, 4–7 mm wide, reflexed; petals



Fig. 20. *Platanthera nivea*, Jackson County, Mississippi.



Fig. 21. Known distribution of *Platanthera nivea* in Mississippi.

spatulate to oblong-linear, denticulate, 4–8 mm long, 3–6 mm wide; lip tripartite, narrowed at base, cuneate, middle lobe with central notch, 15 mm long, 12 mm wide; nectar spur slender, club-shaped, curved, 22–25 mm long. Late June–mid-July. Bottomland hardwoods and adjacent meadows in creek and river floodplains, overgrown pastures, and grassy ditch/pine plantation ecotones. Longleaf Pine Belt/Jackson Prairie transition areas, Jackson Prairie, North Central Plateau, Loess Bluffs, Pontotoc Ridge, and Tennessee River Hills. Rare (NJ and PA to s IL and s MO, s to n GA, n AL, c MS, and n AR). *Platanthera peramoena* at SW periphery of range in MS. State conservation status: **S2S3.**

A spectacular plant, *P. peramoena* sporadically occurs in northern and central Mississippi. The habitat in Attala County is a rich deciduous hardwood forest along a creek. Associated species there are the following: *Acer floridanum, Arisaema dracontium, A. triphyllum, Diospyros virginiana, Ilex opaca, Lilium superbum, Liquidambar styraciflua, Quercus michauxii, Q. pagoda,* and *Q. shumardii*. In a Loess Bluffs/North Central Plateau transition area in Grenada County, *P. peramoena* is in a wet meadow/bottomland hardwoods ecotone in the Yalobusha River floodplain with *Acer rubrum, Fraxinus pennsylvanica,* and *Salix nigra*. As with *P. lacera*, it is difficult to determine specific habitat requirements for *P. peramoena*. Sites supporting populations of this rare species are often nondescript.

Representative specimens examined: **U.S.A. MISSISSIPPI. Attala Co.:** ca. 1.2 mi ENE of Possumneck, on E side of Sharkey Creek, 17 Jul 1997, *Hackett s.n.* (MMNS). **Grenada Co.:** ca. 1.5 mi NNW of Grenada, (T22N, R5E, S6, NW4), low woods/wet meadow ecotone in Yalobusha River floodplain, 8 Jul 1986, *Morris 2269* (mwm), 3 Jul 1987, *Morris 2913* (IBE). **Jasper Co.:** ca. 6.4 mi on FS 507 from junction with Hwy. 15,



Fig. 22. *Platanthera peramoena*, Lafayette County, Mississippi.



Fig. 23. Known distribution of *Platanthera peramoena* in Mississippi.

32.1944, -89.2827, maintained roadside on W side of road, 5 Jul 2004, *Sullivan 04-627* (MMNS). **Lafayette Co.:** shady, sandy swamp, 8 Jul 1916, *Bailey s.n.* (MISS); vicinity of Puskus Creek in Holly Springs National Forest, wet deciduous woods, 20 Jul 1965, *Pullen 65242* (MISS). **Marshall Co.:** ca. 3 mi N of Lafayette-Marshall county line, state hwy. 7, low woods, 28 Jun 1968, *Temple 9529* (MMNS). **Montgomery Co.:** ca. 6.7 mi SE of Winona, weedy overgrown fields and edges of woods, 3 Jul 1982, *Herring s.n.* (MMNS).

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BOOK REVIEW

ROBERT B. SHAW. 2012. **Guide to Texas Grasses.** (ISBN: 978-1603441865, flexbound). University of Texas A&M Press, John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamupress.com, 1-800-826-8911, 1-979-847-8752 fax). $45.00, 1096 pp., 1357 color photos, 34 b/w photos, 947 line drawings, 645 maps, 6.6 lbs, 7" × 10".

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Guide to Texas Grasses is a 7" × 10" flexbound text, consisting of 1096 very thick pages. The text contains numerous color photographs and line drawings for about 670 grasses, both native and ornamental, found in Texas. It is part of the ongoing Texas A&M Nature Guides series edited by Craig Nessler, director of Texas AgriLife Research, and Edward G. Smith, director of the Texas AgriLife Extension Service.

Chapter 1, Why Grasses Are Important, provides a brief summary of the family and discusses the economic importance and uses of grasses such as food, forage, turf and ornamental uses, and biofuels. The chapter also touches on grasses often overlooked relative to their environmental importance for soil conservation and their impact as invasive species.

Chapter 2, The Grass Plant, discusses the morphology of grasses and provides very clear drawings and images of plant parts. Great drawings, many from Barkworth et al. (2003), are included detailing inflorescence types and structures, florets, spikelets, and disarticulation lines. The most detail in spikelets is shown for the Paniceae and Andropogoneae.

Chapter 3, Ecoregions of Texas, briefly discusses the geography of the state and its 12 ecoregions, which are defined as regions with homogenous natural features. The chapter discusses the complex geology of Texas on a broad geologic timescale and how the distinct units were formed over time. The chapter also discusses how physiography, topography, and climate helped determine the different ecoregions and vegetation types. Soils are discussed at the level of soil order. Vegetation areas, natural regions, and land uses are then discussed based on the previously mentioned abiotic factors. A more detailed discussion then begins with a good detailed summary of the 12 ecoregions, their location, dominant species, elevation, geology, soils, climate, and major land use functions. A list of taxa by grass subfamilies is also provided for each ecoregion.

Chapter 4, Classification of the Grasses of Texas, discusses the different subfamilies of the grass family, where they are found dominant, and primarily discusses the different taxonomic classifications and circumscriptions.

Chapter 5, Generic Keys and Species Accounts, are where this book shines. A key to groups is provided at the start of the section, modeling the *Illustrated Flora of North Central Texas* (Diggs et al. 1999). Each group then provides a key to genus, and general illustrations of typical spikelets are provided for each genus. Page numbers are included to facilitate guidance. For each genus, a circumscription is provided as well as keys to species.

(continued on p. 346)

A NEW SPECIES OF *CEROPEGIA* (APOCYNACEAE: ASCLEPIADOIDEAE) FROM INDIA WITH NOTES ON RARE AND THREATENED *CEROPEGIA* IN NILGIRIS OF WESTERN GHATS

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ABSTRACT

Continuing studies in the genus *Ceropegia* in Nilgiri phytogeographical region of southern Western Ghats resulted in the discovery of a new species, **Ceropegia manoharii** Sujanapal, Salim, Anil & Sasidh., sp. nov. Description, illustration and photographs are provided for *Ceropegia manoharii*. Additional study has shed light on the details of three edible *Ceropegia* species, as hitherto undescribed host plants of a butterfly, *Danaus genutia*, and the conservation status.

KEY WORDS: *Ceropegia*, new species, Conservation status, Western Ghats

RESUMEN

Continuando los estudios en el género *Ceropegia* en la región fitogeográfica de Nilgiri del sur de Western Ghats se descubrió una nueva especie, **Ceropegia manoharii** Sujanapal, Salim, Anil & Sasidh., sp. nov. Se aporta una descripción, ilustración y fotografías de *Ceropegia manoharii*. El estudio adicional ha arrojado luz sobre los detalles de tres especies comestibles de *Ceropegia*, como que son plantas hospedadoras de una mariposa, *Danaus genutia*, y su status de conservación.

INTRODUCTION

Nilgiris, or Blue Mountains, the meeting place of three mountain systems of Peninsular India (Chatterjee 1995), is blended with incomparable natural beauty, exceptional physiography, rich biodiversity and blessed climate. The natural habitats vary from montane Shola-Grasslands at Doddabetta, the second highest peak south of Himalayas, to the dry deciduous forests in the lower feet of Deccan plateau in the east and tropical wet evergreen-moist deciduous combinations in the west. Altitudinal arrays from 40 m to 2637 m asl and topographical oddity wrought the region a biodiversity hotspot and the center is the home of several southern Western Ghats endemic and threatened species. Large scale plantations of *tea*, *coffee*, *cardamom*, *eucalyptus*, *pine* and *teak* have resulted in the unprecedented destruction of substantial areas of virgin forests along its scenic valleys. Since the hill stations of Nilgiris are the important tourist destinations in India, anthropogenic engagements shattered the existing natural vegetation. Now, most of the natural habitats, outside the Protected Areas, are highly degraded.

Ceropegia L. (Asclepiadoideae-Ceropegieae), a tropical Old World genus of more than 200 species, exhibits tremendous diversity with respect to habit, habitat, flower architecture and ecological adaptations (Dyer 1983; Bruyns 1997; Kambale et al. 2012). Basely inflated tubular corolla, often lined with downwardly pointed hairs, forms a temporary trap for small flies and the group is widely known as '*fly trap flowers*' (Masinde 2004; Ollerton et al. 2009). Ansari (1984), in the revision of Indian *Ceropegia*, recorded 44 species, of which 28 are reported to be endemic to India. Later six novelties have been added and presently the genus is represented in India by about 50 species, of which 38 are distributed in the Western Ghats (Yadav & Kamble 2008; Yadav & Shendage 2010). Many species of *Ceropegia* are narrow endemics and are placed under different IUCN Red-List categories (Nayar & Sastry 1987–1989).

Ceropegia manoharii Sujanapal, Salim, Anil & Sasidh., sp. nov. (**Figs. 1j–l, 2**). TYPE: INDIA. KERALA: Wayanad District, Meppadi forests, 11°32.369'N, 76°04.553'E, ±1830 m asl, 10 Dec 2009, *P. Sujanapal & P.M. Salim MSSH 0403* (HOLOTYPE: MH; ISOTYPES: CALI, KFRI, MSSH).

Ceropegia manoharii Sujanapal, Salim, Anil & Sasidh. sp. nov., is allied to *C. vincaefolia* Hook. due to the longer corolla lobes than tube; however, it can be easily distinguished from the latter with its fascicled tuberous roots, one- or two-flowered cyme, and elegant green and cream colour combinations of corolla lobes against the single tuberous root, many flowered cymes, and brown and pale yellow combination of corolla lobes. Further, the corolla tube of the new species is hardly dilated above, calyx segments small, peduncle and corolla lobes glabrous whereas in *C. vincaefolia*, corolla tube is funnel shaped, calyx segments long, and peduncle and corolla lobes hairy. Another important peculiarity of the new species is the presence of long, adpressed, brown hairs along the margins of corolla lobes.

Twining herbs; secondary root tuberous, few, to 30 cm long, 1–1.5 cm diam.; stem to 0.5 cm diam., terete, glabrous, branched. Leaves simple, decussate, thickly coriaceous; petiole 0.8–1.5 cm long; lamina 5–10 × 2–3.5 cm, lanceolate, apex acuminate, base rounded or acute, dark green, shining above, pale green below, margin smooth, laxly ciliate. Cymes axillary or extra axillary, mostly one- or two-flowered; peduncle 0.8–1.2 cm long, ca. 1.5 mm diam., glabrous; pedicel 1.8–2.4 cm, ca. 1 mm diam., glabrous; bract solitary, 2–4 × 0.2–0.5 mm, linear, acuminate, glabrous. Sepal 3–5 × 0.6–0.9 mm, linear, acuminate, glabrous. Corolla 3–4 cm long; tube 1.4–1.8 cm long, greenish yellow, dilated at base, conical with sudden constriction above, striated with purplish brown lines on the upper half, glabrous, mouth of the inflated part with inwardly directed hairs inside, inner deeply purple; lobes 1.6–2.2 cm long, strictly and completely folded back along midrib, linear oblong with rounded apex, lower half creamy white internally with an artistic roundish end, externally with brown blotches, upper half dark greenish, margin with long brown adpressed hairs, lobes connate at tip forming an ovoid head. Outer corona cupular, lobes 5, each lobe bifurcate into two divergent horn-like projections, each projection ca. 1.5 mm long, ciliate, horns of adjacent lobes paired apically; inner corona of five linear, connivent, purple lobes, ca. 2.5 mm long, apically rounded. Pollinia yellow, attached to the brown corpusculi by short caudicles; pollinarium 0.3 × 0.25 mm in total. Follicle pairs unequal, larger 15–18 × 0.3–0.4 cm and the smaller 10–13 × 0.3–0.4 cm, slightly curved, glabrous; seeds ca. 5 × 2 mm, ovate-oblong, black; coma 0.8–1.5 cm long, white, silky.

Local status and Population.—Rare in the locality, a total of 44 mature individuals were located in the Montane Grasslands of Meppadi Forest Range. Most of the growing spots are inaccessible due to steep cliffs and sharp rocky cuttings.

Habitat.—Grasslands between 1500–1850 m asl.

Geographical distribution.—So far known only from the montane grasslands of South Wayanad Forest Division (Nilgiri, Western Ghats, Kerala, India).

Etymology.—The specific epithet '*manoharii*' derived from a Malayalam word '*manoharam*' which means beautiful, denotes the elegant flowers of the new species.

Flowering and Fruiting.—August–February.

PARATYPES.—**INDIA. Kerala:** Wayanad District, Meppadi forests, 11°32.372'N, 76°04.568'E ±1800 m asl, 20 Dec 2010, *P. Sujanapal & P.M. Salim MSSH 0412*; 12 Jan 2011, *P. Sujanapal & P.M. Salim MSSH 0428*.

Distribution and Habitat of *Ceropegia* Species in Nilgiris

During the study, a total of nine taxa of *Ceropegia* were collected from Nilgiris. Among the collections an undescribed, elegant species was included, named here as *Ceropegia manoharii* Sujanapal, Salim, Anil & Sasidh. sp. nov., shows a very narrow distribution in the Meppadi Hill ranges of Wayanad. Except *C. hirsuta* and *C. juncea*, all other species are endemic to the Peninsular India - Sri Lanka mega-diversity center. *Ceropegia juncea* Roxb., a leafless species with succulent stem is restricted to dry habitats towards the eastern side of Nilgiris. Species such as *C. manoharii*, *C. ciliata* Wight, and *C. thwaitesii* Hook. are confined to montane wet grasslands. *Ceropegia candelabrum* L. is found in the moist deciduous forests and similar areas. *Ceropegia decaisneana* Wight, *C. hirsuta* Wight & Arn., and *C. elegans* Wall. are occurring in evergreen forests and similar habitats above 500 m asl. Most of the species of *Ceropegia* in this region are habitat specific with a narrow distribution range. Therefore, they are highly vulnerable and deserve special attention for conservation.

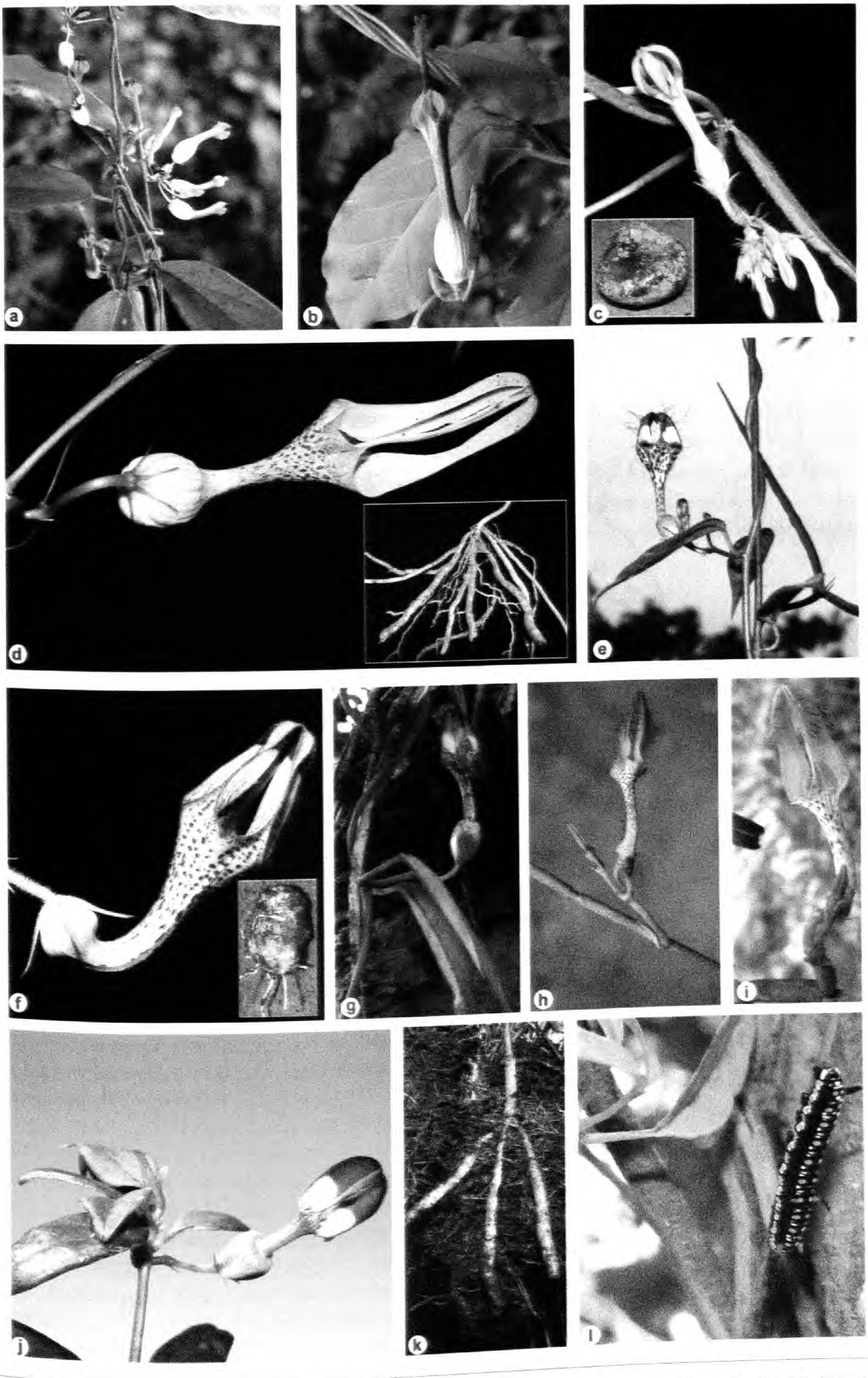


Fig. 1. Diversity of *Ceropegia* in Nilgiris. **a,** *Ceropegia candelabrum* ssp. *candelabrum*; **b,** *C. candelabrum* ssp. *tuberosa*; **c,** *C. ciliata*; **d,** C. *decaisneana*; **e,** C. *elegans*; **f,** *C. hirsuta*; **g,** C. *thwaitesii*; **h–i,** *C. juncea*; **j–l,** *C. manoharii* (**j.** flower; **k.** fleshy (tuberous) secondary roots; **l.** caterpillar of *Danaus genutia*) (inset – tubers).

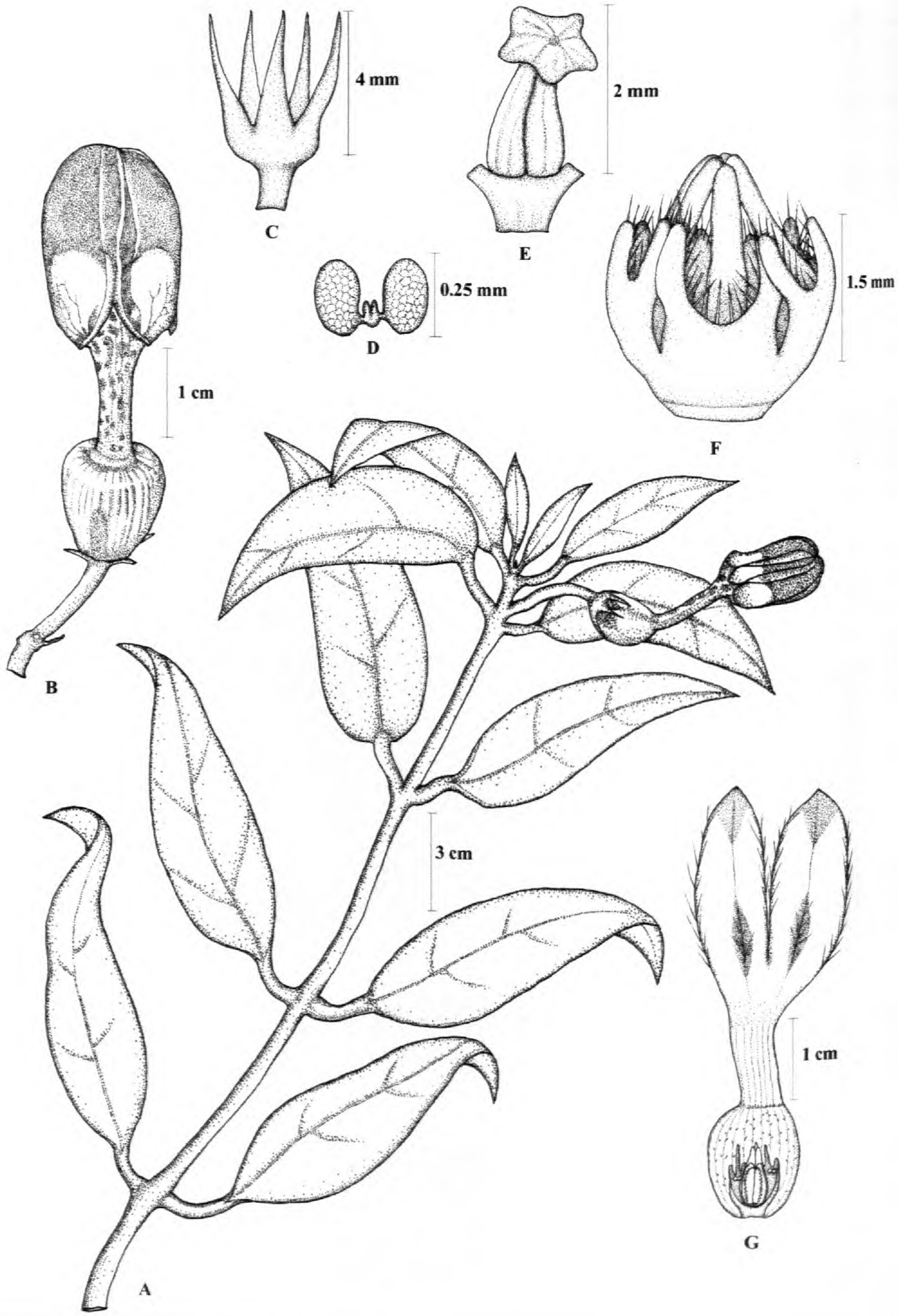


FIG. 2. *Ceropegia manoharii* Sujanapal, Salim, Anil & Sasidh., sp. nov. **A.** flowering twig; **B.** flower; **C.** calyx; **D.** pollinarium; **E.** carpel; **F.** corona; **G.** flower, l.s.

Socio-ecology of *Ceropegia* of Nilgiris

The genus *Ceropegia* is characterized by root tubers either as single large potato-like tuber or fascicled tuberous roots. Tubers and leaves of many species of *Ceropegia* are used as food in various parts of the Old World (Mabberly 1987). It is also used in indigenous systems of medicines (Pullaiah 2006). Inquiry with the tribes, as well as other local people of the study area, revealed that tubers of *C. hirsuta* and leaves of *C. decaisneana* are consumed by local communities. Though *C. decaisneana* doesn't form a potato-like tuber, the leaves are used as '*Paalaancheera*' (Milk tasted Amaranth) and are a delicious item during the fasting period such as '*Eidh*'.

Rare and Threatened Species and Horticultural Importance

Among the nine taxa collected from the study area, seven are endemic to *Western Ghats-Sri Lanka Biodiversity Hotspot* and three taxa are restricted to southern Western Ghats region. Among the three Western Ghats endemic species *C. decaisneana* is already listed in the Vulnerable category of IUCN; species such as *C. ciliata* and *C. manoharii* are very rare and facing a higher threat than the *red-listed* species due to various anthropogenic and environmental factors.

Ceropegia is distinctive with magnificent flowers and a few species have leafless succulent vines; because of this peculiarity, many species of *Ceropegia* are widely cultivated as ornamental plants. Observation revealed that species such as *C. juncea, C. manoharii, C. elegans, C. decaisneana,* etc., are suitable for gardening. Since many of these species are host plants of butterflies, they will attract butterflies to the gardens. It is found that the caterpillar of the butterfly, *Danaus genutia,* feeds on *C. elegans, C. thwaitesii* and the newly described *C. manoharii.* These species are hitherto undescribed host plants of *Danaus genutia.*

ACKNOWLEDGMENTS

Authors are thankful to S.R. Yadav, Kolhapur University, Maharastra; Peter Bruyns, Bolus Herbarium, South Africa; David J. Goyder, Kew Herbarium; U.K, Ulrich Meve, University of Bayreuth, Germany; Siddharthan Surveswaran, University of Hong Kong and V.C. Balakrishnan, Kannur for relevant literatures, critical comments, expert opinion, and identification of the caterpillar. Thanks also to two anonymous reviewers for a careful review of an earlier draft. We are thankful to Kerala Forest Department for their help during the field-work. First author is thankful to SERC, DST for fast track fellowship. We extend our heartfelt thanks to the tribal communities and local people, who contributed traditional knowledge during the study.

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BOOK REVIEW

ROBERT B. SHAW. 2012. **Guide to Texas Grasses.** (ISBN: 978-1603441865, flexbound). University of Texas A&M Press, John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamupress.com, 1-800-826-8911, 1-979-847-8752 fax). $45.00, 1096 pp., 1357 color photos, 34 b/w photos, 947 line drawings, 645 maps, 6.6 lbs, 7" × 10".

(continued from p. 340)

Somewhat frustratingly here, a number is given for each species to facilitate direction, but page numbers would likely be more helpful. Each species contains a brief circumscription and general habitat, an illustration of the plant and florets, and a map of known Texas counties in which it occurs—though it would be helpful for the circumscriptions to have mentioned complete distributions, beyond just Texas. Live images, growth form, and inflorescence are often included as well. My only complaint is that the species circumscription does not include any information about typical fruiting and flowering times. The circumscription could also be more detailed regarding morphology, making it a tad more difficult to obtain a positive identification from the key, but illustrations drawn to scale often make up for this. The illustrations are wonderful, though, and often take up half of the page, so they are very easy to see.

The **appendix** provides a section on collection, preparation, handling, and storage for grass specimens that should be very useful for new collectors. This section also discusses type designations and the importance of vouchers and provides a how-to for collecting, pressing, and labeling herbarium specimens. Also provided in this section is a list of herbaria in Texas, their addresses, specialties, specimen numbers, and herbarium codes. While this is helpful, some of the information is incorrect or already out of date, and it would be wise to verify this information with Index Herbariorum (www.nybg.org).

All in all this is a great resource for anyone, amateur or professional, looking to learn more about Texas grasses. *Guide to Texas Grasses* is not a field guide by any means; it is bulky and heavy, even as a paperback, and requires the user to have some experience using dichotomous keys. But it's a great manual and resource to keep in a car or on a desk. It has unusually thick paper for a text of this sort, which makes the impeccable photographs all that more useful, but will also help maintain the life of the text, as pages will not tear easily. I would recommend *Guide to Texas Grasses* to anyone wanting to delve into the magical world of grasses.—*Rebecca K. Swadek, Field Biologist, New York City Natural Areas Conservancy, and Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

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A NOTE ON "*ERITRICHUM* SCHRAD. 1819" AND *ERITRICHIUM* SCHRAD. EX GAUDIN 1828 (BORAGINACEAE)

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ABSTRACT

Eritrichum Schrad. was not validly published. *Eritrichium* Schrad. ex Gaudin is valid and the correct name for the genus.

KEY WORDS: *Eritrichum*, Boraginaceae

RESUMEN

Eritrichum Schrad. no se publicó válidamente. *Eritrichium* Schrad. ex Gaudin es el nombre válido y correcto para el género.

During a routine analysis of a draft treatment for the *Flora of North America*, Volume 15, we encountered a nomenclatural problem with a genus name and its type species.

While assembling material for an examination of the North American *Eritrichium*, we found that both "*Eritrichum* Schrad. (1819: 186)" and *Eritrichium* Schrad. ex Gaudin (1828: 4, 57) have been used. Schrader's genus name, if it were to be validly published, would have priority over Gaudin's *Eritrichium*.

A sampling of monographs, revisions, and floras shows an inconsistency in spelling and citations. Wight (1902: 407), Lechner-Pock (1955–1956: 100), and Weber (1990: 113) considered Schrader's 1819 publication valid and used "*Eritrichum*". DeCandolle (1846:122), Popov (1953: 482), Cronquist (1959: 202), Ohwi (1965: 757), Hultén (1968: 773), Scoggan (1979: 1284), Ovchinnikova (2009: 142) and Zhu & al. (1995: 378, following IPNI, see below) accepted Schrader as the author of the genus but spelled the genus name *Eritrichium*, which is a preference they can exercise in cases of orthographic variations. Abrams (1951: 557) and Johnston (1924: 51), while using the spelling *Eritrichium*, gave the citation as Schrader *in* Gaudin. Finally, Chater (1972: 117), Cronquist (1984: 222), and Welsh & al. (2003: 61) used *Eritrichium* Schrader ex Gaudin.

The International Plant Name Index (IPNI 2012a) has the genus name and its bibliography as: "*Eritrichium* Schrad. in Comm. Gotting. iv. (1820) 186, in obs. (Eritrichum). Asperifol. 16." Index Nominum Genericorum (Plantarum) (ING 2012) listed "*Eritrichium* Schrader ex Gaudin, Fl. Helv. 2: 4, 57. 1828." Additionally, the Names in Current Use (NCU-3e; 2012) has essentially the same as ING.

Schrader (1819: 186) distinguished many taxa found in the Boraginaceae based on the form of the carpophore (= fruiting receptacule): Type "1. *Immutata s. plana* [s. = seu = or], omnium frequentissima, cum discus fructu maturescente formam non mutat, ut in Symphyto *p*), Boragine, Echio etc.; 2. *convexa*, cum discus per maturitatem fructus magis vel minus elevatur, ut in Myosoti, in plurimis Anchusae speciebus *q*) et varus aliis; 3. *cónica* l. [l. = licet = that is] *hemisphaerico - conica*, cuius siimilis cum praecedente ortus: Eritrichum (*Myosotis nana*), *Pulmonaria virginica* et affines species, distinctum genus constituents."

The question is whether the Type 3 character "conica l. hemisphaerico-conica" applies to *Eritrichum* alone or to two genera: *Eritrichum* (*Myosotis nana*) and an unnamed genus (*Pulmonaria virginica* and allied species). If the key character does indeed apply to *Eritrichum* alone, then the genus name was validly published by Schrader. On the other hand, if the key character applies to both *Eritrichum* and an unnamed genus, then the genus name is not valid.

We have concluded that the key character does apply to both *Eritrichum* and an unnamed genus, and the name was not validly published by Schrader. Therefore, Gaudin's (1828) validation of the name *Eritrichium* is accepted.

Eritrichium is typified by *E. nanum*, which was based on *Myosotis nana* L. The validity of *M. nana* (published in Amann, Fl. Alp. 13. 1756) has been questioned. The protologue is: Myosotis nana Bocc. T. 107 (1697).

The Linnean Typification Project (2012) does not list this name on its website. IPNI (2012b) treated *M. nana* L. as invalid and provided a remark: "The name doesn't appear in any of Linnaeus's later works and it is thought to be an abbreviated reference to Boccone's phrase name (Museo Piante Rare Sicil. t. 107. 1697) not the publication of a new binomial (C. Jarvis, pers. comm.)."

After a discussion with IPNI's editorial staff at Kew, the name *Myosotis nana* is deemed valid and the above remark is revised to: "The name is thought by some to be an abbreviated reference to Boccone's phrase name (Museo Piante Rare Sicil. t. 107. 1697) rather than publication of a new binomial (C. Jarvis, pers. comm.)" (IPNI, 2012c).

Thus the correct citation of the generic name is as follows:

Eritrichium Schrad. ex Gaudin, Fl. Helv. 2:4, 57. June 1828. TYPE SPECIES: *E. nana* (L.) Gaudin (*Myosotis nana* L. [correct authority is Linnaeus, not Amman or Villars or Allioni]

Eritrichum Schrad., Comment. Soc. Regiae Sci. Gott. 4:186. Dec 1819, nom.nud.

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BOOK REVIEW

CHARLES R. HATCH. 2007. **Trees of the California Landscape: A Photographic Manual of Native and Ornamental Trees.** (ISBN: 9780520251243, hbk). University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012, U.S.A. (**Orders:** www.ucpress.edu, orders@cpfsinc.com, 1-800-777-4726, 1-800-999-1958 fax). $63.00, 542 pp., >1000 color illus. (photos, line drawings, maps), 8 ½" × 11".

Contents:

Foreword
Introduction
The California Landscape
- *Topography*
- *Geography*
- *Climate*

Trees in the Native Landscape
- *Regional native trees*
- *Classification of native vegetation*
- *Vegetation series dominated by trees*
- *Native vegetation types and habitats*
- *The interface: transitions between native and urban landscapes*

Trees in Urban Landscape Design
- *Trees in urban landscape design*
- *Types of urban landscapes*
- *Arrangement of trees*
- *Trees in various contexts*
- *Codes and ordinances affecting tree planting*
- *Design elements in tree selection*
- *Planting and irrigation*
- *Creative applications and special effects*
- *Culture and maintenance*
- *Special use and applications lists*

Trees of the California Landscape (Compendium)
Taxonomy
Tree Structure
General Characteristics
Leaf Types
Leaves
Flower Types
Fruit Types
Glossary
Distribution of Trees by Classification
Trees by Family
Key to Tree Genera
Key to Tree Species
Index to Trees
Index to Common Names
Arboretums
Bibliography

Trees of the California Landscape is an 8 ½" × 11" hardcover book of 542 pages. It contains numerous color photographs, color drawings, and maps encompassing the entire state of California and its many vegetational zones from the coast across the Central Valley, to the Cascades, Sierras, and the Mojave and Sonoran deserts. All together, this text contains morphological descriptions, habitat information, photographs (leaves, bark, and habit), and drawings for 107 native and 311 ornamental species.

This text is very integrative, describing the relationships between vegetation, geography, topology, and climate—without excluding man's effects on vegetation and landscape. The introduction gives a very brief overview of the text and some of the major vegetational zones. The next section discusses the effects of topology, geography, and climate, with excellent maps. Also useful are three (north, central, and south) cross sectional diagrams of California topology, which describe how topology affects climate in each of these regions.

There is a full section describing the native California vegetation classification. Maps show the distribution of vegetation types in the state and give lists of typical vegetation from that particular ecosystem. Here, Hatch discusses the importance of sustainable human interaction with native landscapes and advocates for "bioregional" landscapes, which incorporate the features of the native environment into parks and housing developments. He argues that this type of low impact and low input development is more "ecologically sound" and "establishes a deeper connection to the natural processes" of nature. Examples include grading and

(continued on p. 354)

NOTES ON *ERITRICHIUM* (BORAGINACEAE) IN NORTH AMERICA

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ABSTRACT

Lectotypes are chosen for *Eritrichium chamissonis* and *E. aretioides*.

RESUMEN

Se escojen lectotipos para *Eritrichium chamissonis* y *E. aretioides*.

Typification of *Eritrichium chamissonis* DC. and selection of a lectotype.

Eritrichium chamissonis DC. is a small, cushion-forming plant of the Bering Strait region, which is how Wight (1902) and then Hultén saw it (1968). Later, however, Hultén (1973) came to believe that he had been led astray by Wight who applied *E. chamissonis* to the plants with flowers included within or barely exerted from the cushion of stems and leaves. Hultén's change in thinking was brought about by two errors. First, he decided that a cushion form should be named *E. aretioides* (Cham.) DC., because Popov's (1953) illustration of "aretioides" showed a densely pulvinate plant (Plate 25, fig. 1), and second, Hultén believed the type specimen of *E. chamissonis* had long flowering stems, which is at odds with the original description of de Candolle (1846).

As to the first assumption, Jurtzev and Petrovsky (1980) determined that Popov had unknowingly illustrated a distinct, densely pulvinate species, not *Eritrichium aretioides*, but one that had gone unrecognized until the publication of *E. tschuktschorum* Jurtzsev & V.V. Petrovsky, which on leaf morphology alone is readily separable from both *E. aretioides* or *E. chamissonis*.

As to the second assumption, the descriptions by de Candolle of *Eritrichium aretiodes* and *E. chamissonis* are brief, and the two species are not well differentiated; nevertheless, he made clear that *E. chamissonis* is a plant with the shorter stems of the two. In fact, the flowers of *E. chamissonis* at anthesis rise no farther than the surface of the tuft, whereas *E. aretioides* has flowering stems well above the tuft. Some *E. aretioides* plants are densely compact, but differ from *E. chamissonis* in the length of the flowering stem and thus the position of the flowers. Hultén had no reason to doubt Wight's account.

De Candolle (Prodromus 10:125. 1846) published a description of *Eritrichium chamissonis* based on specimens originating at LE, collected by Chamisso or Eschscholtz during the voyage of the *Rurik* 1816 or 1817. De Candolle referred unequivocally and unambiguously to St. Lawrence Bay, "ad sinum Sancti-Laurentii ad fretum Beering (Cham.!)" but then continued "in Kamtchatka (h. ac. Petr.!)", thus at least two localities and thus two specimens, or syntypes, were the basis for his new species. He added a direct reference to what Chamisso had reported earlier (Chamisso & Schlechtendal, Linnaea 4:442. 1829) as *Myosotis villosa* Ledeb., but obviously not all of the plants so named by Chamisso were regarded by de Candolle as *M. villosa*. Chamisso in his account was clear that the locality for his *M. villosa* was St. Lawrence Bay. He made no reference to Kamtchatka.

A review of the type sheet at G-DC was undertaken, first with excellent digital images provided by G, then with a visit to G. Mounted on the type sheet at G-DC are two collections. The one from Kamchatka, collector unknown, provided to de Candolle by a colleague at LE ("h. ac. Petr.!" in the original description). This specimen is labeled *Myosotis villosa* Ledeb., and with its strongly exerted, leafy flowering stems, does not match the description of *Eritrichium chamissonis*: "... racemulis pauciflorus brevissime exertis," instead it clearly resem-

bles *E. villosum* (Ledeb.) Bunge. This specimen cannot be considered as *E. chamissonis*. Why de Candolle would make a direct reference to the Kamchatka specimen is a curious contradiction of his own description.

The other specimen on the type sheet, also labeled *Myosotis villosa*, is a specimen that matches the description of *Eritrichium chamissonis* as the flowers barely exceed the cluster of sterile, leafy shoots, and it is clearly attributed to Chamisso. However, this one is labeled "St. Lorenz insel" meaning St. Lawrence Island,. This specimen, while a perfect match with the description of de Candolle, is in conflict as to location. However, the *Rurik* visited both St. Lawrence Bay, Chukotka, and St. Lawrence Island, Alaska, during its voyages.

De Candolle took the locality Lawrence Bay directly from what Chamisso (in Chamisso and Schlechtendal 1829) had written under *Myosotis villosa*. Yet, neither of the two specimens on the type sheet is from St. Lawrence Bay. That de Candolle failed to add St. Lawrence Island to his description, despite the label on the sheet before him, must have been a *lapsus calami*. It is otherwise impossible to reconcile the discordance.

An herbarium sheet at LE bearing Chamissio's signature *breve*, labeled *Myosotis villosa*, and from St. Lawrence Bay, would seem to be what is referred to in the description of *Eritrichium chamissonis*, but it is clearly not consistent with it, inasmuch as the flowering stems are tall, leafy, rising well above the basal leaves, thus closer in habit to *E. villosum* or *E. aretioides* than to *E. chamissonis*. That sheet cannot be considered as the basis for *E. chamissonis*.

Another LE sheet has been labeled, incorrectly, as holotype by Ovchinnikova (2008). The specimens are attributed to Eschscholtz. Ovchinnilova (2008) reported the locality as "Sin. St. Laur[enti]"; the handwriting on the original labels attached to that sheet is not easy to decipher. Who wrote that note is not known (V.V. Petrovsky, pers. comm.). There is no evidence at LE or G-DC that this material was seen by De Candolle.

Not found at LE is a sheet with specimens of *Eritrichium chamissonis* from St. Lawrence Island from which the specimen on the type sheet at G-DC might have been taken. The source of that specimen at G-DC remains unknown.

Nevertheless, de Candolle did have before him and most certainly he based his description of *Eritrichium chamissonis* on the Alaskan specimen. De Candolle did not designate a type, therefore, there can be no holotype. The specimen, a syntype, on the type sheet at G-DC from St. Lawrence Island, Alaska, is designated here as lectotype for *E. chamissonis* DC.

Eritrichium chamissonis DC., Prod. 10:125. 1846. TYPE: ALASKA: St. Lawrence Island (LECTOTYPE, designated here: G-DC! G00204592, top plant).

Typification of *Eritrichium aretioides* (Cham.) DC. and selection of a lectotype (with a contribution by Kanchi N. Gandhi).

It is known from Chamisso and Schlechtendal (1829) that Chamisso collected his new species *Myosotis aretioides*, mixed with *M. villosa*, at St. Lawrence Bay, Chukotka, and also from St. Lawrence Island Alaska. Since two localities were given by Chamisso, the name *M. aretioides* must be based on one or more of the syntypes, and a lectotypification is necessary.

Ovchinnikova (2008) cited an Eschscholtz specimen from St. Lawrence Island ("Ins. St. Laurentii. Eschscholtz") at LE as holotype of *Myosotis aretioides*. Although her incorrect usage of the term "holotype" could be taken as a case of implied lectotypification (cf., Melbourne Code Art. 9.9; McNeill & al. 2012), she did not lectotypify the name. This is because for any advertent lectotypification of a name done from 2001, the typifying author must include the phrase "designated here" or its equivalent (Melbourne Art. 7.10). Therefore, it is concluded that Ovchinnikova did not lectotypify *M. areteoides* and that the name needs a formal lectotypification.

The "type sheet" for *Myosotis aretioides* at G-DC has three specimens mounted on it. One of these can be dismissed as unrelated to *M. aretioides*. Another is from the Academy in St. Petersburg (LE) with a printed label *Myosotis aretioides*, Sinus st. Laurentii, but a collector not recorded. The third bears a handwritten label with the signature *breve* of Chamisso, from Insula St. Laurenti, determined *M. aretioides* with the symbol for *mihi*. This would be better as the type for *M. aretioides*. Whereas a specimen at LE seen by Chamisso would have

greater standing, there is no Chamisso specimen at LE from which the one at G-DC might have been taken or one that better represents Chamisso's intentions. Since the specimen at G-DC was determined by Chamisso and furthermore connects Chamisso to de Candolle, that specimen is designated here as lectotype.

Myosotis aretioides Cham., Linnaea 4:443. 1829. TYPE: ALASKA: St. Lawrence Island, Chamisso s.n. (LECTOTYPE, designated here: G-DC! G00204671, right-hand plant).

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BOOK REVIEW

CHARLES R. HATCH. 2007. **Trees of the California Landscape: A Photographic Manual of Native and Ornamental Trees.** (ISBN: 9780520251243, hbk). University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012, U.S.A. (**Orders:** www.ucpress.edu, orders@cpfsinc.com, 1-800-777-4726, 1-800-999-1958 fax). $63.00, 542 pp., >1000 color illus. (photos, line drawings, maps), 8 ½" × 11".

(continued from p. 350)

drought tolerant landscaping to preserve native oak forests in new developments and the use of floodplains for open grassy park corridors instead of buildings.

The discussion on the use of trees in urban landscapes is very useful for landscapers and homeowners. This section discusses different types of landscaping, purposes, tree arrangement, shape, spacing, and planting requirements of different trees. Lists are provided for different colored flowering trees, white barked trees, fall colors, long-lived trees, desert accents, tropical accents, and more.

There are excellent sections at the end of the book showing leaf shape, cone and fruit shapes, and other morphological characteristics of different species. Following these is a glossary of terms and a dichotomous key to genus.

This book provides an excellent overview of California ecology that would be useful to many different disciplines, including landscape designers, teachers, naturalists, homeowners, etc. In fact, the only complaints I have about this text are map errors. In one error, Mariposa County is incorrectly labeled as Fresno County, so Fresno County appears twice in maps containing county labels. Another error is for the species page of Joshua Tree where the distribution map for California Bay on the previous page was duplicated, giving an incorrect distribution for Joshua Tree. Something to consider for a revised or second edition!—*Rebecca K. Swadek, Field Biologist, New York Natural Areas Conservancy, and Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

A REVIEW OF THE NEOTYPIFICATION OF *ASTROPHYTUM CAPRICORNE* VAR. *CRASSISPINUM* (H. MÖLLER) OKUMURA (CACTACEAE)

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ABSTRACT

We review Momberger's (2007) designation of a neotype for *Astrophytum capricorne* var. *crassispinum*. The morphological evidence indicates that the neotype (ULM-18572) seriously conflicts with Heinrich Möller's (1925) original description of this taxon. Momberger's assertion that the *Astrophytum* population from Sierra Agua Chiquita, Coahuila, Mexico, is var. *crassispinum* is incorrect. Under the provisions of ICBN, Article 9.17*b*, we recommend that ULM-18572 be set aside and superseded by another element. We designate ZSS-019963 as the neotype for var. *crassispinum* for its morphology agrees with the original description.

RESUMEN

Se revisa la designación de Momberger (2007) de un neotipo de *Astrophytum capricorne* var. *crassispinum*. La prueba morfológica indica que el neotipo (ULM-18572) está en serio conflicto con la descripción original de Heinrich Möller (1925) de este taxón. La afirmación de Momberger de que la población de Sierra Agua Chiquita, Coahuila, México, es var. *crassispinum* es incorrecta. En virtud de lo dispuesto en el ICBN, Artículo 9.17*b*, se recomienda que ULM-18572 debe rechazarse y ser reemplazado por otro elemento. Designamos ZSS-019963 como neotipo para la var. *crassispinum* pues su morfología está de acuerdo con la descripción original.

ZUSAMMENFASSUNG

Wir überprüfen Momberger's (2007) Bestimmung eines Neotypus für *Astrophytum capricorne* var. *crassispinum*. Die morphologischen Daten zeigen, dass der Neotypus (ULM-18572) ernsthaft in Konflikt mit Heinrich Möller's (1925) Original-Beschreibung dieses Taxons steht. Momberger's Behauptung, dass die *Astrophytum* Population der Sierra Agua Chiquita, Coahuila, Mexiko, die var. *crassispinum* sei, ist falsch. Nach den Bestimmungen des ICBN, Artikel 9.17b, empfehlen wir, ULM-18572 aufzuheben und durch ein anderes Element zu ersetzen. Wir bezeichnen ZSS-019963 als Neotypus für die var. *crassispinum* da seine Morphologie mit der Original-Beschreibung übereinstimmt.

KEY WORDS: *Astrophytum*, botany, Coahuila, Cuatro Cienegas, taxonomy

INTRODUCTION

In 1925, Heinrich Möller described *Echinocactus capricornus* var. *crassispinus* [sic] based on a series of specimens collected by his brother, Arthur Möller, who resided in San Pedro de las Colonias, Coahuila, Mexico. The original series collected by Arthur Möller was shipped to Heinrich Möller for purposes of study and description. About half of the plants in the original series had sparse, irregularly scattered woolly flecks on the epidermis; the remaining plants were completely nude and green. The spines were very stout, somewhat flattened, and numbered from 6 to 8 per areole. The flower was described as canary yellow with a sulfurous yellow throat. The number of specimens in the original series was not mentioned and no photographs accompanied the original description. Furthermore, Heinrich Möller did not designate a holotype nor did he state if any specimens from the original series were deposited in a herbarium. The absence of such information, as well as the failure to find this plant at the type locality (see below) set the stage for a decades-long debate (*fide* Momberger 2007) concerning the existence and identity of this taxon.

The type locality of Möller's var. *crassispinum* was given as the Sierra de Parras, but no collector has ever found plants matching the original description in that mountain range. Through the efforts of many collectors, the occurrence of *Astrophytum capricorne* var. *senile* in the western part of the Sierra de Parras has been well documented (Hoock 2008, and references therein). It also occurs in the Sierra Baicuco (= Sierra de las Buras, Sierra de la Peña) and Cerro Bola, but not yet recorded from the small outlier range, the Sierra Mayran. Farther

east, in the region near Parras de la Fuente, Říha and Bušek (1986) reported the occurrence of *Astrophytum capricorne* var. *capricorne* (A. Dietr.) Britton et Rose.

In 1930, the eminent cactus collector, H.W. Viereck, discovered an *Astrophytum* in the vicinity of Cuatro Cienegas, Coahuila, Mexico (Bernhard & Hoock 1986). The collected specimens belonged to the *capricorne* group, but differed from the type species in having stout, flattened spines (usually 6 to 8 per areole), a large stem size (a maximum of 50 cm in height), and an epidermis densely covered with short, white hairs (trichomes) having a felt-like texture. Viereck's discovery was obviously morphologically similar to the previously described var. *crassispinum*. Kayser (1933) described and named the population from the vicinity of Cuatro Cienegas as *Echinocactus capricornis* var. *niveus*.

In 1933, plants identified as *Astrophytum capricornus* var. *crassispinus* [sic] were featured on postcards created by Otto Stoye. The postcard photographs included both nude and sparsely flocked specimens from the private collection of Kurt Kreuzinger (Hoock 2008:162). Our examination of the postcards led us to conclude that the plants were very similar to those described by Heinrich Möller in 1925. The plants may have been imported from Coahuila by A.V. Fric, who was a known associate of K. Kreuzinger, but the precise locality information was never published.

In 1985, a locality for "*crassispinum*-like" plants in "northern Coahuila" was discussed in an *Astrophytum* "ring letter" which included a photograph of the habitat. Ulrich Bernhard and Heinz Hoock searched for, and found the locality by matching the mountains in the photo with the actual mountain range on the landscape. The locality was situated approximately 42 km west of Cuatro Cienegas; the habitat and its plants were described by Bernhard and Hoock (1986). The authors reported that densely flocked, white plants (var. *niveum*) and totally nude, green plants (which the authors called the "nude form" of *Astrophytum capricorne* var. *niveum*) occur together in the habitat in approximately equal numbers. But intermediate (sparsely flocked) plants were encountered only very sporadically (Fig. 1). Similar observations concerning the relative abundance of flocked, nude and sparsely flocked plants were also reported by Baumann (1992). Although no quantitative data were presented, the sporadic occurrence of sparsely flocked plants was surprising considering the likelihood of cross-pollination between the white and green forms.Říha and Bušek (1986) described variation in the spine morphology and epidermal flocking of these *Astrophytum* from the locality west of Cuatro Cienegas. The authors noted, aside from the typical var. *niveum*, several forms including nude plants with white, yellow, and dark brown spines and yellow flowers.

Various authors, including Megata (1944), Haage and Sadovský (1957 a,b), Sadovský and Schütz (1979), Ito (1981), and Bušek (1981) regarded the nude and sparsely flocked plants with stout spines as "*crassispinum*". It could not be determined whether the plants illustrated by these authors originated from a single locality or from several different localities, or if any came from 42 km west of Cuatro Cienegas. Říha and Bušek (1986), Bernhard and Hoock (1986), Baumann (1992), Hoock and Kleszewski (2006), and Hoock (2008) all indicated that the nude plants from west of Cuatro Cienegas were morphologically similar to Möller's *crassispinum*.

In 2007, Momberger reported the surprising discovery of the "missing" *Astrophytum capricorne* var. *crassispinum*, claiming that this taxon occurs along the western slopes of the Sierra Agua Chiquita. This mountain range is a northern extension of the Sierra de la Purisima which forms the eastern margin of the Bolson de Cuatro Cienegas. The latter is nearly divided into eastern and western basins (bolsons) by the Sierra San Marcos. Momberger accorded this *Astrophytum* population formal taxonomic recognition as *Astrophytum capricorne* subsp. *senile* var. *crassispinum* and designated a neotype (ULM-18572) which was deposited in ULM (Herbarium Universität Ulm, Germany).

Pavlíček (2011) subsequently described the Sierra Agua Chiquita population of *Astrophytum* as a new subspecies, *Astrophytum capricorne* (A. Dietr.) Britton et Rose subsp. *sanjuanense*. He designated a section of a rib with spines as the holotype: PR 745389, Department of Botany of the National Museum, Praha (Prague), Czechoslovakia.

As a consequence of Momberger's discovery, there are now two *Astrophytum* populations that potentially qualify as Möller's var. *crassispinum*. We review the morphological data pertaining to the eastern and western

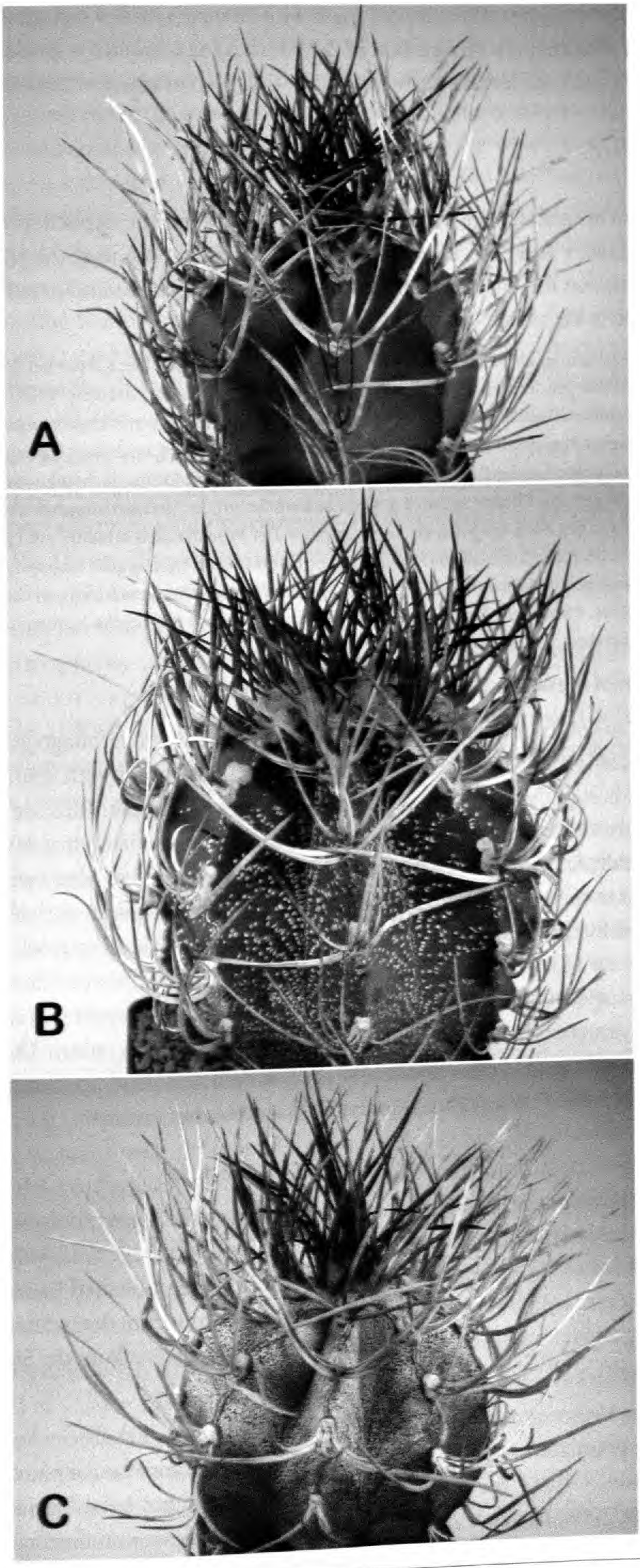


FIG. 1. Examples of (**A**) the completely nude, (**B**) sparsely flocked, and (**C**) densely flocked *Astrophytum* plants from the locality 42 km W of Cuatro Cienegas, Coahuila, Mexico.

bolson populations of *Astrophytum* and compare them with Heinrich Möller's original description. Our purpose is to determine if Momberger's recognition of the Sierra Agua Chiquita population as var. *crassispinum* and his designation of a neotype for this taxon should be accepted or rejected under the provisions of ICBN Article 9.17.

ORIGINAL DESCRIPTION

The original description of *crassispinum* by Heinrich Möller (1925) is quite explicit, presenting morphological information on the vegetative and generative traits of this taxon. In our opinion, the potential of attaching this name to a natural population has always existed owing to the completeness and detail of Möller's description. The original description reads as follows:

Körper einfach, kugel- bis kegelförmig, 15 cm hoch, 8–9 cm im Durchmesser, laubgrün. Der Körper bei der einen Hälfte der erhaltenen Pflanzen ist absolut nackt, der Körper der anderen Pflanzen ist mit spärlichen, regellos zerstreuten Wollflöckchen bedeckt. Der Scheitel wenig eingesenkt, mit wenig gelbem Wollfilz versehen. Rippen stets 8, scharfkantig. Areolen 20 mm voneinander entfernt, länglich, bis 6 mm gross, mit reichlich gelblichen Haaren, die später vergrauen und verfilzen. Stacheln 6, höchstens 8, plattgedrückt, sehr dick, in der Jugend braunschwarz, später grauweiss, kreidig. Das unterste Paar ist am stärksten, bogenförmig nach links und rechts von der Pflanze abstehend, die Spitze nach oben gebogen. Die Pflanze ist durch das sehr lockere Gewirr der Stacheln umgeben, da dieselben nicht abgebrochen oder bestossen werden. Blüten in der Nähe des Scheitels, ca. 6 cm gross. Der Fruchtknoten schlank, mit spitzigen Schüppchen bedeckt. Blütenröhre mit reichlicher Wolle. Blütenhülle trichterförmig. Äussere Hüllblätter schmutzig gelb, zugespitzt; innere spatelförmig, gezähnelt, kanariengelb, seidenglänzend. Der Schlund der Blüte ist nicht karminrot, sondern schwefelgelb, wachsartig. Die Staubgefässe kaum halb so lang wie die Blütenröhre. Fäden gelb, Beutel etwas dunkler. Der Stempel hat 8 hellgelbe Narben und überragt die Staubgefässe. Frucht und Samen wie beim Typ und den anderen Varietäten.

Our English translation of the original description reads as follows:

Body simple, spherical to conical in shape, 15 cm high, 8–9 cm in diameter, foliage-green. The body of half of the obtained plants is completely naked; the body of the others is covered with sparse, irregularly scattered wooly flecks. The apex is slightly depressed, covered with a little yellow felt. Ribs are always 8, sharp-edged. Areoles are 20 mm apart, oblong, to 6 mm in size, with abundant yellowish hairs, which later turn gray and dingy. Spines 6, maximally 8, flattened, very thick, black-brown in youth, later gray-white, chalky. The bottom pair is strongest, bowed to the left and right and standing away from the plant, with the tips curved upwards. The plant is surrounded by the loose tangle of spines which do not break off or prick each other. Flowers are near the apex, about 6 cm tall. The ovary slender, covered with pointed scales. Flower tube with abundant wool. Perianth funnel-shaped. Outer tepals acuminate, dirty yellow; inner tepals spatulate, denticulate, canary yellow and satiny. The throat of the flower is not crimson, but sulfur-yellow, waxy. The stamens barely half as long as the corolla tube. Filaments yellow, anthers slightly darker. The pistil has 8 bright yellow stigma lobes and towers above the stamens. Fruit and seeds as in the type and other varieties.

MORPHOLOGICAL COMPARISONS

Morphological comparisons of the *Astrophytum* population from the western bolson (42 km west of Cuatro Cienegas), and the Sierra Agua Chiquita population from the eastern bolson, with Möller's (1925) original description are presented below. Comparative data are drawn from the published literature, but the published information is supplemented by our direct observations of these plants from the habitat and from horticultural material. In comparing Möller's original description with the *Astrophytum* from the Sierra Agua Chiquita, the following points are made:

1) The plants studied by Möller consisted of completely nude as well as sparsely flocked plants in nearly equal proportions. The population from the Sierra Agua Chiquita is comprised of plants having sparse, irregularly scattered woolly spots, but completely nude plants have not been found (Hoock & Kleszewski 2006; Momberger 2007; Pavlíček 2011). Furthermore, as far as we can determine, none of the several persons visiting the habitat in the Sierra Agua Chiquita (F. Gottschlich, F. Jahn, K.P. Kleszewski, P. Pavlíček, W. Sporbert) has ever reported finding completely nude plants.
2) Möller (1925) described the new spines of *crassispinum* as having a black-brown color, turning gray-white

with age. But, Momberger (2007) described the new spines as straw-colored in the plants from the Sierra Agua Chiquita. Hoock and Kleszewski (2006) also described the plants from this mountain range as having new spines with a golden-yellow hue, becoming dirty gray with age. Pavlíček (2011) described the new spines as gray-yellow, the older spines being predominantly gray in color and slightly frayed. In culture, we have noted some plants with reddish brown spines. However, such plants are the exception; the most common color is golden yellow or straw-colored. If Möller had observed any plants in his original series with yellow spines at the stem apex he would have certainly mentioned it. Significantly, there are no reports of plants from the Sierra Agua Chiquita with new spines of a black-brown color.

3) In Möller's original description of *crassispinum*, the spines are described as "flattened" and "very thick," 6 to 8 per areole. According to Momberger (2007) the plants from the Sierra Agua Chiquita have 6 to 8 (–10) spines. Pavlíček (2011) gave a slightly higher number, stating there are always more than 8, and usually 10 to 12 spines. According to Möller (1925) the bottom pair of spines is strongest, bowed to the left and right and standing away from the plant, with the tips curved upwards. In plants from the Sierra Agua Chiquita, this trait is only weakly expressed. Momberger (2007) stated that the bottommost pair is mostly flattened and the upper spines mostly round. Pavlíček (2011) described them as flexible, slightly angular, and in some specimens almost triangular. He stated that they are only slightly stronger than in the subspecies *senile*. Direct comparisons reveal that the spines of the Sierra Agua Chiquita plants are not as stout as those of the plants from the western Bolson de Cuatro Cienegas, but compare favorably with the spines of var. *aureum* from the Sierra de la Paila (Fig. 2).

4) The blossoms of the *Astrophytum* from Sierra Agua Chiquita are yellow with a red throat, but the red color is usually reduced, and in exceptional specimens the throat is pure yellow, brownish or honey-yellow (Hoock & Kleszewski 2006; Momberger 2007). Pavlíček (2011) described the flower throat as reddish-brown, brown-yellow or pure yellow. Only the yellow-throated specimens agree with Möller's original description of the flowers.

Momberger's assertion that the plants from the Sierra Agua Chiquita are the missing *crassispinum* may have been influenced by photos published in Haage and Sadovský (1957b) and Sadvoský and Schütz (1979). We acknowledge that the photos show close agreement with the *Astrophytum* from the Sierra Agua Chiquita (see Fig. 3 for a comparison). However, a critically important point must be made here. The published photos are not of the original material collected by Arthur Möller. They represent plants collected by H.W. Viereck and sent to Brno, Czechoslovakia, and credited to Konrad Kayser and Sadovsky himself (Sadovský & Schütz 1979:152). Therefore, Momberger's statement that the photos depict the "real" *crassispinum* is unsupported and clearly in error.

We are of the opinion that the plants described by Momberger conform generally well to a population of *Astrophytum capricorne* var. *aureum* characterized by prominent, but sparse, white spots on a green or bluish-gray-green epidermis. Our taxonomic concept follows that suggested by Hoock and Kleszewski (2006). However, we are prepared to defer to Pavlíček's (2011) taxonomic conclusion that the Sierra Agua Chiquita population represents a new subspecies, although obviously related to the var. *aureum* populations from the Sierra de la Paila.

A comparison of the plants from the western bolson (42 km west of Cuatro Cienegas) with Möller's original description is presented below. As previously stated, we draw upon published information as well as direct observations of plants in habitat and culture. The following points are made:

1) The original material collected by Arthur Möller included completely nude and sparsely flocked plants. The populations west of Cuatro Cienegas include completely nude, sparsely flocked, and densely flocked plants. While the presence of nude and sparsely flocked plants is consistent with the specimens comprising the original series, the presence of densely flocked (var. *niveum*) plants is problematic, and requires further discussion (see below, ***Remarks on Type Locality***).
2) New spines emerging from the apex of the stem are usually black-brown in color, becoming gray-white with age, and hence agree with Heinrich Möller's original description.
3) The original description of *crassispinum* states that the spines are "flattened" and "very thick", numbering 6 to 8 per areole. The bottom pair of spines is strongest, bowed to the left and right and standing away from

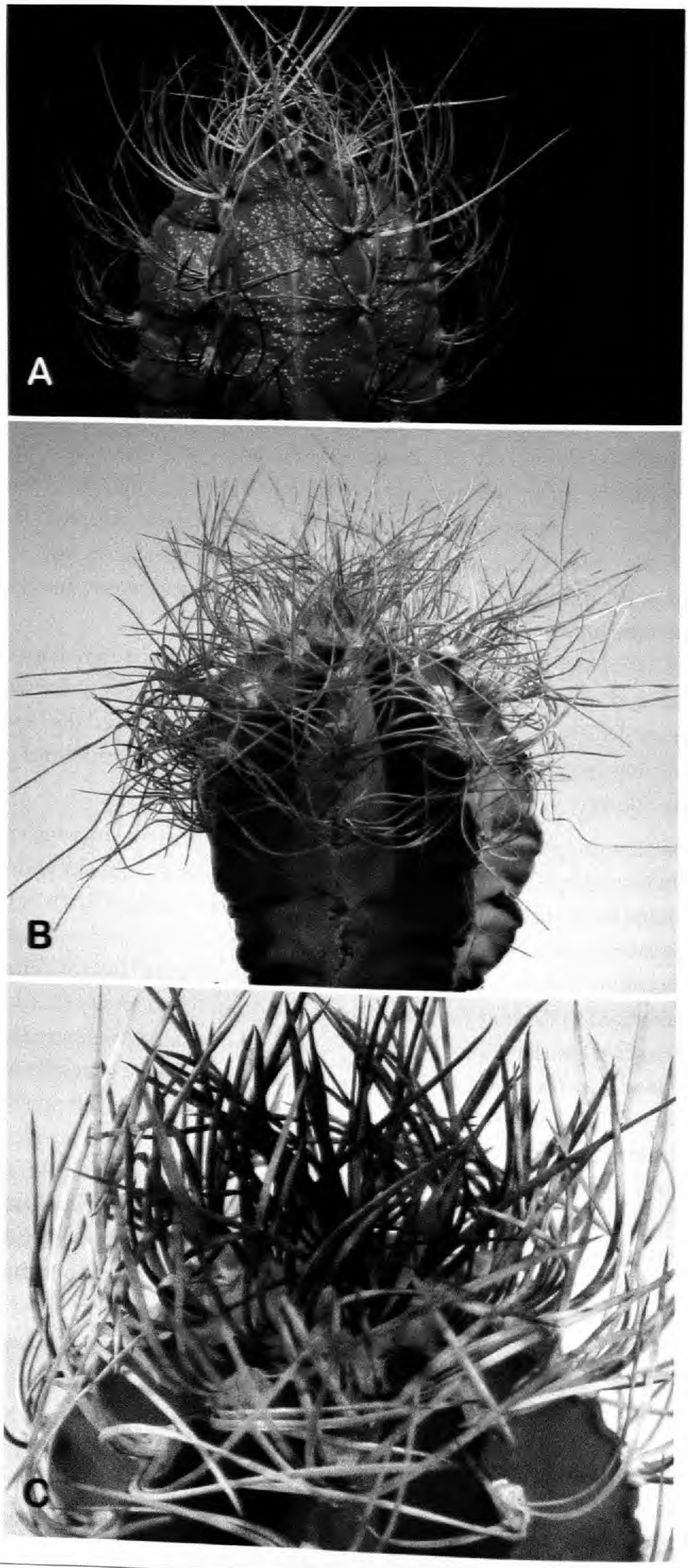


Fig. 2. Comparison of the spines of *Astrophytum* plants from (**A**) Sierra Agua Chiquita, (**B**) Sierra de la Paila (var. *aureum*) and (**C**) west of Cuatro Cienegas, Coahuila, Mexico.



FIG. 3. Photo from (**A**) Haage and Sadovský (1957b) of var. *"crassispinum,"* compared with a photo (**B**) by Werner Sporbert in Momberger (2007), showing the close similarity between the two plants. See text for further discussion.

the plant, with the tips curved upwards. The spines of the plants from the western bolson are very stout, somewhat flattened, and usually number from 6 to 8. Typically, the bottom pair is strongest and characteristically bowed to the left and right with the tips curved upwards. As mentioned previously, the spines are considerably stouter than those of plants from the Sierra Agua Chiquita population, and better fit the concept of the name "*crassispinum*." Apparently, Heinrich Möller was quite impressed by the thickness of the spines which he described. Also, he had in his possession at the same time var. *aureum* for the purpose of publishing a taxonomic description in the same paper (Möller 1925). His published descriptions are detailed, indicating that he had excellent knowledge of the comparative morphology of the two taxa. Momberger (2007) suggested that the name "*crassispinum*" is a misnomer which resulted in a misconception of the spine morphology of this taxon. However, Momberger's opinion is not supported by evidence. We note that the concept of the name is compatible with the detailed description of the spine morphology given by Möller (1925).

4) Möller's original description states that the throat color of the flower is sulfurous yellow. In plants from the western bolson, the throat varies from peach to orange or orange-red, and in relatively few specimens the throat color is pure yellow. Říha and Bušek (1986) reported that among a series of 12 plants, four plants (33.3%) had exclusively yellow throats; the remaining eight had red color in the center. These plants originated from seed material procured by A.B. Lau in 1977 from the western bolson. Heinrich Möller did not state how many blossoms he observed in the original plant material, and therefore it is not known if the flowers displayed variation comparable to that observed among the plants from the western bolson. It is possible that H. Moller observed flowers from a small subset of the original series of plants and thus was not aware of any color variation. Alternatively, the original plant material may have been collected from a colony in which yellow throat color was locally fixed. In any case, we regard the departure from the original description to be of minor significance considering that the variation of the population includes yellow throat color.

CONCLUSIONS

The plants from the Sierra Agua Chiquita described as var. *crassispinum* by Momberger (2007) differ by several significant morphological characters from Möller's original description of *crassispinum*. In the Sierra Agua Chiquita plants, the new spines have a yellow or straw color; the spines are relatively slender with an angular, triangular or rounded cross-sectional shape, and the population is comprised of sparsely flocked plants; completely nude plants have not yet been found. In contrast, the *Astrophytum* population from the western bolson (42 km W of Cuatro Cienegas) agrees quite closely with Möller's original description. The plants have new spines with a black-brown color; the spines are very stout with a slightly flattened cross-sectional shape; the bottom pair of spines is strongest, bowed to the left and right and standing away from the plant, with the tips curved upwards. Flower color is variable, but at least some plants in the population have a yellow throat. Entirely nude as well as sparsely flocked plants occur in the population. The primary discrepancy is the presence of heavily flocked plants at the location 42 km W of Cuatro Cienegas. We offer explanations for this discrepancy below.

The evidence presented above reveals that Momberger's designated neotype (ULM-18572) seriously conflicts with Heinrich Möller's original description of var. *crassispinum*. Therefore, we recommend that under the provisions of ICBN, Article 9.17*b*, the neotype (ULM-18572) be set aside and superseded by another element. It is our contention that neotypification is essential for taxonomic stability. The designation of another specimen as the neotype is warranted because there is apparently no surviving plant material from Möller's original description of 1925. Furthermore, the name *crassispinum* should be attached to a herbarium specimen in order to prevent any ambiguity with other known taxa or with new taxa potentially discovered in the future. Therefore, we here designate ZSS-019963 (Fig. 4) as the neotype of var. *crassispinum* for its morphology agrees with Heinrich Möller's original description.

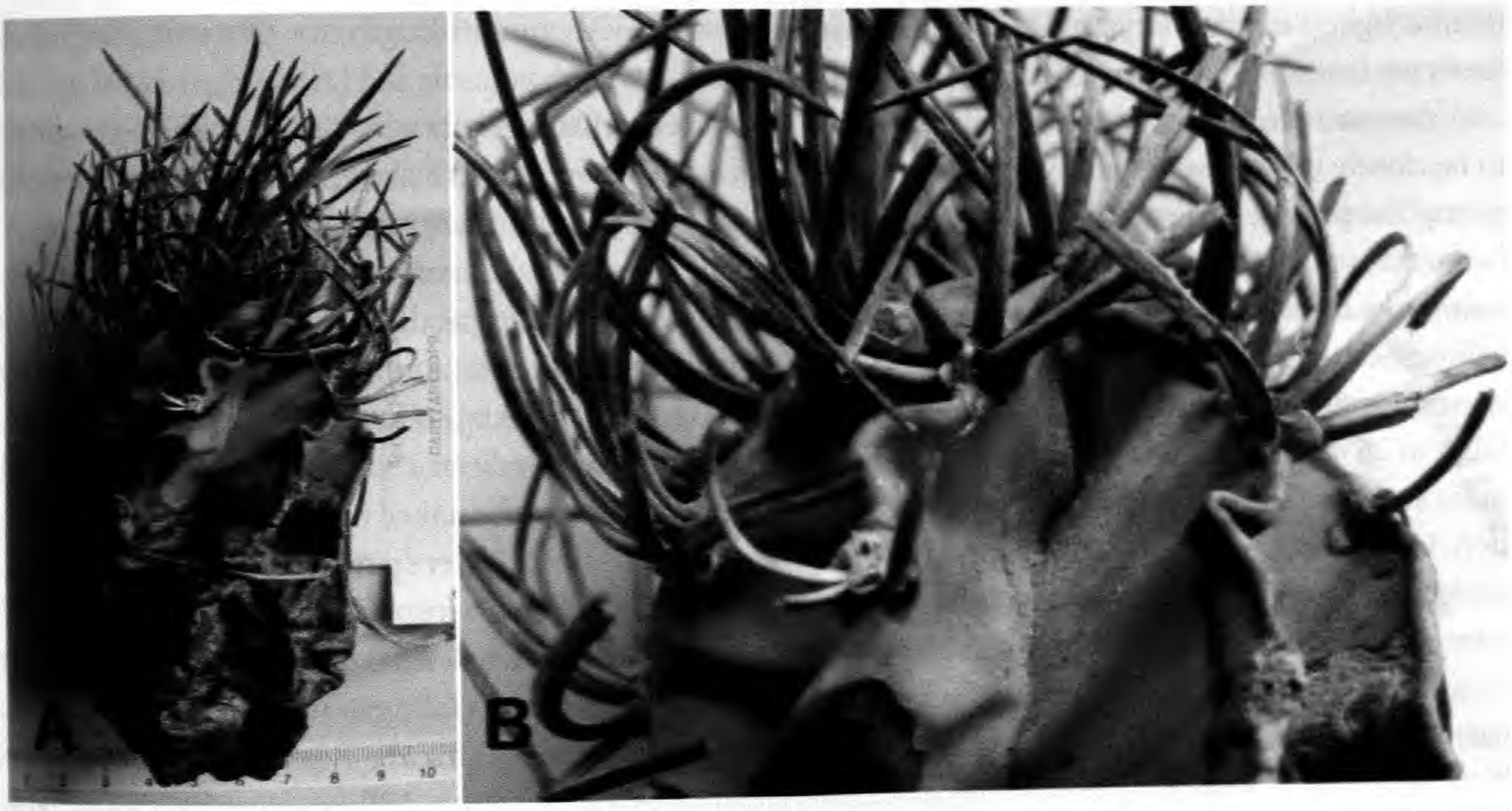


FIG. 4. The neotype (ZSS-019963) of *Astrophytum capricorne* var. *crassispinum* showing (**A**) the entire plant and (**B**) the close-up of spines.

REDESCRIPTION

Astrophytum capricorne (A. Dietr.) Britton & Rose var. **crassispinum** (H. Möller) Okumura, Syaboten-no-Kenkyu 4:175. 1933. *Echinocactus capricornus* A. Dietr. var. *crassispinus* H. Möller, Z. Sukkulentenk. 2:129. 1925. TYPE: MEXICO. COAHUILA: cultivated plant without associated locality data, 42 km W of Cuatro Cienegas de Carranza, ca. 1980s, *Heinz Swoboda s.n.* (original NEOTYPE, designated by Momberger 2007: ULM-18572; new NEOTYPE, here designated: ZSS-019963).

Note.—The neotype is a cultivated plant without associated locality data. However, we have information that the collector, Heinz Swoboda, visited the habitat west of Cuatro Cienegas around the 1980s (see also Pavlíček 2011). We tentatively restrict the type locality to 42 km west of Cuatro Cienegas de Carranza, Coahuila, Mexico.

Astrophytum capricorne var. *crassispinum* f. *major* A.F. Möller, in Okumura, Syaboten-no-Kenkyu 5:103. 1934.

Astrophytum capricorne var. *crassispinum* f. *minor* A.F. Möller, in Okumura, Syaboten-no-Kenkyu 5:103. 1934.

A revised description of var. *crassispinum*, with additional morphological data from plants in cultivation and from the habitat, is herewith presented. Statistics of dispersion include the sample mean ± two standard errors followed by the observed limits in parentheses.

Description.—Body single, young plants spherical, short columnar with age, pale to dark leaf green; stem up to 35 cm in height; epidermis nude or only sparsely flocked with white spots comprised of short hairs (trichomes). Ribs always 8, sharp-edged. Areoles ± oval, ca. 6 mm in long diameter, 20 mm apart, with abundant yellowish to whitish hairs, later turning whitish gray and dingy. Plant body surrounded by a loose tangle of spines. Spines (–5)6–8(–11) somewhat flattened, very stout, rather stiff, up to 85 mm long; new spines at apex black-brown, becoming gray-white with age. Bottommost pair strongest, bowed to the left and right, directed away from stem, with tips curved upward. Plants from west of Cuatro Cienegas agree with this description of the spines although there is considerable individual variation (see photos in Říha & Bušek 1986). Flower diameter is 77.8 mm ± 3.5 mm (60–104 mm) in 44 flowers; ovary slender, covered with pointed scales; flower tube with abundant wool; perianth funnel-shaped; outer tepals acuminate, dirty yellow; inner tepals spatulate, denticulate, canary yellow and satiny; flower throat waxy, varies from peach to orange to orange-red to red, rarely sulfur-yellow or honey-brown; stamens barely half as long as corolla tube; filaments yellow, anthers slightly darker; style with 7.5 ± 0.3(4–12) yellow stigma lobes in 91 flowers. Fruit red or pale green with reddish base; dehiscence basal in circular fashion; seeds usually connected by funiculus at hilum to ovary; fresh fu-

niculus light pink, later drying. Seeds cap-shaped, 2.7 mm (2.5–3.0 mm) in length; n = 30 seeds. Number of seeds per fruit: 146(96–280); n = 32 fruit.

Comparisons.—Variety *crassispinum* and var. *niveum* are morphologically very similar and are presumed to be closely related sister taxa. Var. *niveum*, however, is densely covered with short, white hairs (trichomes), giving the plant a snow white and felted appearance. Also the plants are slightly larger, reaching 50 cm in height; maximum recorded height for *crassispinum* is 35 cm. As described above, var. *crassispinum* shows variation in the throat color of its flowers; in var. *niveum* the flower center is typically scarlet, but also rarely pure yellow (Schätzle 1988). The flower of var. *niveum* is similar in diameter and number of stigmata to that of var. *crassispinum*. Flower diameter is 74 mm ± 4.4 mm (60–80 mm) in 10 flowers; style with 8.4 ± 0.6 (6–12) stigma lobes in 25 flowers. When the two varieties are compared at the same body size, var. *crassispinum* usually has more areoles with spines. The greater density of spines may help protect the naked epidermis from solar radiation. In var. *niveum*, the dense covering of trichomes may compensate for fewer spines by providing the necessary protection from solar radiation. In both varieties, there are uncommon forms in their respective populations which have new spines with a whitish to yellowish color (Říha & Bušek 1986).

Remarks on Type Locality.—The type locality for var. *crassispinum*, originally given as the Sierra de Parras, has been a source of controversy for many years inasmuch as plants matching the type description have not been found there. Some authors have speculated that Heinrich Möller may have deliberately misstated the type locality as a diversionary tactic (Říha & Bušek 1986). However, this seems improbable for a man of his professional standing; more likely, he would have simply withheld such information in the interest of plant conservation. Furthermore, in Möller's description of var. *aureum* (in the same article with var. *crassispinum*) the origin of the plants is correctly stated. His brother, Arthur Möller, would probably not have deliberately misled him about the type locality, for he had provided accurate locality information for other new taxa sent previously. It is possible that A. Möller inadvertently mislabeled the specimens or simply neglected to mention where they had been collected, leading Heinrich Möller to assume the plants originated from the Sierra de Parras which is relatively close to San Pedro.

The tentative restriction of the type locality deserves comment. Arthur Möller's collection of plants included both nude and sparsely flocked individuals in nearly equal proportions. Assuming he collected plants randomly from the habitat, the relative numbers of sparsely flocked and nude plants in his series would have corresponded to their relative abundance in the habitat. At the present time, the populations at 42 km west of Cuatro Cienegas are comprised primarily of nude plants (var. *crassispinum*) and densely flocked plants (var. *niveum*), with sparsely flocked plants being quite scarce. There are at least two possible explanations for the apparent discrepancy. If Möller collected his series at this locality, a natural change in relative abundance may have occurred since 1925 with the densely flocked plants increasing at the expense of the sparsely flocked plants (perhaps caused by a strengthening of an incipient reproductive isolating mechanism between the two varieties). The other explanation is that Arthur Möller collected his series from a different location, perhaps farther west or southwest and away from the densely flocked population. This would then account for the absence of *niveum*-like plants in the series he collected. In support of this possible explanation, we are aware of one undisclosed, distant locality where nude and sparsely flocked plants of var. *crassispinum* have been observed, but no examples of var. *niveum* have yet been found.

The extent to which var. *crassispinum* and var. *niveum* exchange genes in nature is unknown and merits detailed study. Baumann (1992) regarded the sparsely flocked plants as "intermediates" (presumed hybrids?) between the two varieties. We have produced sparsely flocked plants (as well as nude ones) by crossing two pure green plants, thereby demonstrating that they can arise through genetic recombination and are not necessarily F_1 hybrids. Artificial F_1 hybrids should be produced to determine the density of flocking on the epidermis. Also, var. *niveum* plants from 42 km W of Cuatro Cienegas should be inter-crossed to determine if any of the resulting seedlings are partly or completely devoid of pubescence.

Taxonomic Remarks.—As presently conceptualized, *Astrophytum capricorne* consists of approximately seven varieties; additional varieties may yet be described. As all of these taxa are treated equally as varieties

under the type species, the classification system does not accurately reflect their relationships and evolutionary history. Momberger (2011) has attempted to rectify this situation by the simultaneous use of the categories of "subspecies" and "variety" for some taxa. Whether this system will be well received or rejected by taxonomists remains to be seen.

In reviewing the descriptions of these taxa, we have determined that in some cases there are insufficient morphological data for proper taxonomic diagnosis. It is evident that the "*capricorne* group" is in need of careful study in order to determine the number of valid taxa, their rank, interrelationships and evolutionary history. Future research should include not only detailed morphological analysis, but molecular genetic analysis as well. In addition, the roles that physiographic features, *viz.* Desierto de Mayran, have played as vicariance factors in the evolution of the "capricorne group" members should be investigated.

ACKNOWLEDGMENTS

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BOOK REVIEW

FRED DORTORT. 2011. **The Timber Press Guide to Succulent Plants of the World.** (ISBN: 9780881929959, hbk). Timber Press, The Haseltine Building, 133 S.W. Second Avenue, Suite 450, Portland, Oregon 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 1-800-327-5680, 1-503-227-3070 fax). $49.95, 344 pp., 755 color photos, 2 maps, 8 ¾" × 11 ¼".

The author's opening comment in his preface states, "The first time I visited a succulent plant nursery, I felt as if I'd been handed the key to an odd but very interesting room. I saw plants there that resembled flowers, plants that looked like rocks, and plants that fit no familiar description at all." He was totally "hooked"! Or, as he wrote, "... the owners themselves...were both extremely enthusiastic and extraordinarily knowledgeable about their plants." And, obviously, so was he.

Dortort was attracted to Berkeley's University of California Botanical Garden, fascinated by their "scientifically organized" plant collections and smitten with the desire to get involved. Soon he armed himself with a paperback book and headed "to the great Southwest to look for the rarest, most localized plants in North America." This was the beginning of his extensive and thorough work with succulents.

This is not only a beautifully illustrated book, it is carefully planned: descriptions are well written and thorough. While most of us think we're fairly knowledgeable about succulents, the comprehensive inclusion of both photographs and carefully written descriptions bring the reader into a far more extensive awareness of the many diverse species. One can spend hours gazing at the incredible diversity of plants included in this genre.

Chapter 1 explains and beautifully illustrates the diversity of succulents as they grow in nature. Chapter 2 gives an overall description and illustrations of succulents in cultivation. Chapters 3–29 deal with specific genera.

Dortort does an excellent job of describing the various genera, carefully explaining various locations, plant parts, and the many unusual aspects of these plants. Not only is the photography outstandingly clear and beautiful, the diversity of types, locations, and distinctively different shapes are astounding—strange, unexpected, sometimes beautiful, and fascinating!

This is a volume for which the reader will need—and want!—to take ample time to look at illustrations, carefully read descriptions, and keep going back and forth through the pages, fascinated by the unexpected beauty and diversity of these genera.—*Helen Jeude, Volunteer & Assistant Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

A FOSSIL FLOWER OF THE GENUS *PROTIUM* (BURSERACEAE) IN MID-TERTIARY AMBER FROM THE DOMINICAN REPUBLIC

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ABSTRACT

Protium callianthum (Burseraceae) is described as a new species of fossil flower from amber deposits in the Dominican Republic. The flower is functionally staminate and is characterized by a cupular calyx with 5 triangular lobes, 5 widely recurved petals (1 missing through insect predation or mechanical damage), 10 incurved stamens with laterally dehiscent anthers, and an enlarged, annular disc surrounding a small pistillode. The ovary is glabrous and 5-lobed, with a fused style and spreading, 10-lobed stigma. Features consistent with many extant *Protium* species are petals with papillate margins and a minutely papillate adaxial surface, and stamens of two slightly unequal series, the antepetalous being longer than the antesepalous. This is the 12th angiosperm species recently described in Mid-Tertiary amber from Neotropical Caribbean forests.

RESUMEN

Se describe **Protium callianthum** (Burseraceae) como una nueva especie de flor fósil procedente de los depósitos de la Republica Dominicana. La flor es funcionalmente estaminada y se caracteriza por un cáliz cupular con 5 lóbulos triangulares, 5 pétalos ampliamente recurvados (1 perdido por predación de insectos o daño mecánico), 10 estambres incurvados con anteras dehiscentes lateralmente, y un disco anular ensanchado que rodea un pequeño pistilodio. El ovario es glabro y 5-lobulado, con un estilo fusionado y extendido, estigma 10-lobulado. Sus características consistentes con muchas especies vivientes de *Protium* son pétalos con márgenes papilosos y superficie adaxial diminutamente papilosa, y estambres de dos series ligeramente desiguales, los antepétalos más largos que los antesépalos. Esta es la duodécima especie de angiosperma recientemente descrita en ámbar del terciario medio en bosques Neotropicales Caribeños.

INTRODUCTION

Previously described fossil angiosperms from the Dominican amber deposits include 3 species of Arecaceae (Poinar 2002a, 2002b)), 3 of Meliaceae (Chambers et al. 2011b; Chambers & Poinar 2012), 2 of Lauraceae (Chambers et al. 2011a, 2012b), 1 of Fabaceae (Poinar 1991), 1 of Chrysobalanaceae (Poinar et al. 2008a; revised by Chambers & Poinar 2010), and 1 possibly of Moraceae (Poinar et al. 2008b). The habitat for these taxa was a moist tropical forest, from which numerous amber-embedded insect and plant fossils are known (Poinar & Poinar 1999). The family Burseraceae, order Sapindales, is most closely related to family Anacardiaceae (Stevens 2001 onwards; Wannan 2006). It contains about 700 species in 19 genera found principally in tropical and subtropical areas of the Old and New Worlds (Daly et al. 2011). Based on DNA evidence from plastid and nuclear markers, the age of Burseraceae has been estimated as 64.92 (60.33-69.67) Ma, near the Cretaceous/Tertiary boundary (De-Nova et al. 2012). This is considerably younger than the estimated date of 92.7 Ma of Becerra et al. (2012). Fossil evidence of the Burseraceae, principally in the form of fruits and pyrenes, first becomes abundant in the Early Tertiary (Daly et al. op. cit., p. 87). *Protium* is one of the largest genera in the family, with ca. 180 species, ranging in the New World from southern Mexico to Amazonia and in the Old World from Madagascar to India, tropical China, and the Malesian region (Daly et al. op. cit.). It is almost entirely arborescent, with various species providing sources of resin and durable timber (Mabberley 2008).

MATERIALS AND METHODS

The described flower, together with an accompanying one missing its reproductive organs (see Fig. 5), are in a single piece of amber collected from mines in the Dominican Republic, in the Cordillera Septentrional between the cities of Puerto Plata and Santiago. The amber is principally deposited in turbiditic sandstones of the Upper

Eocene to Lower Miocene Mamey Group (Draper et al. 1994). The age of the amber is controversial, the oldest assigned dates being 45–30 Ma, based on coccoliths (Cépek in Schlee 1999), and the youngest being 20–15 Ma, based on foraminifera (Iturralde-Vinent & MacPhee 1966).

DESCRIPTION

Protium callianthum K.L. Chambers & Poinar, sp. nov. (**Figs. 1–5**). TYPE: HISPANIOLA. DOMINICAN REPUBLIC: amber mine in the northern mountain range (Cordillera Septentrional), 2010, *unknown amber miner s.n.* (HOLOTYPE: catalogue number Sd-9-191, deposited in the Poinar amber collection maintained at Oregon State University, Corvallis, Oregon 97331, U.S.A.).

Flower 5-merous, staminate, width at anthesis (estimated from fully developed petals) 6.0 mm (Figs. 1, 2), calyx glabrous, cupular (Fig. 4), 1.4 mm long overall, sepals connate, the fused portion 1.0 mm, the lobes broadly triangular, acute, 0.4 mm long, 0.7 mm wide at base; petals 5 (1 missing and 1 truncated near base), lanceolate from a broad base, acute, spreading, distal portion recurved, length 2.4 mm including the recurved part, the tip inflexed (Fig. 4), margin papillate (Fig. 4), abaxial surface glabrous, adaxial surface minutely papillate; stamens 10, strongly incurved, of 2 different lengths, the antepetalous ones up to 1.1 mm, the antesepalous ones up to 0.9 mm, anthers lance-linear, basifixed (Fig. 2), 0.5 mm long, laterally dehiscent; disc intrastaminal, glabrous, annular, swollen, 1.7 mm in diameter, the central depression 0.7 mm in diameter, occupied by a reduced pistillode (Fig. 2), ovary ovoid, glabrous, ca. 5-lobed, style fused, stout, 0.15 mm long, distally 10-lobed or sulcate (Figs. 1, 2), floral pedicel papillate at base, otherwise glabrous, 2.8 mm long (Fig. 3).

Etymology.—From Greek "kallos," beauty, and "anthos," flower.

DISCUSSION

Petals of *Protium* may be either erect or reflexed at anthesis (Engler 1931), and the fossil is in the latter category. Petals are variously glabrous or pubescent in the genus, e.g., villous abaxially and adaxially in *P. alvarezianum* Daly & P. Fine and adaxially short-papillate in *P. carolense* Daly. The fossil resembles the latter species in this respect as well as in its widely recurved petals, but differs in other features (e.g., flowers 5-merous versus 4-merous). The form of calyx seen in *P. callianthum* is well represented in the genus, as described for many of its species by Swart (1942). Anthers with basal rather than dorsal insertion are common in the genus and characterize *P. callianthum* (Figs. 2, 3). They are illustrated for *P. altsonii* Sandw., *P. bahianum* Daly, and others (Daly 1989, 1992a). Staminate flowers possessing a thick intrastaminal disc whose central depression contains a reduced, nonfunctional but structurally complete pistil, are common in *Protium* (see illustrations of *P. bahianum* [Daly 1992a] as well as *P. morii* Daly and other taxa [Daly 1992b]). The ease with which the fossil keys to *Protium* on floral traits (Swart 1942; Daly et al. 2011), as well as its similarity to the various illustrated taxa mentioned above, strongly support its assignment to this genus.

Several features of the fossil are worth noting. Papillate margins allow postgenital fusion between the valvate petals before they finally separate at anthesis. This occurs through interdigitation of the papillae, as explained by Bachelier and Endress (2009). A striate cuticular ornamentation, which they also mention, is not visible in the fossil. The occurrence of antepetalous stamens longer than the antesepalous ones, as in the fossil, was noted for *Protium morii* by Bachelier and Endress (2009) from floral bud cross-sections. However, this differs from the description of the species by Daly (1992), who gives 1.7–1.85 and 1.85–2.05 mm for the antepetalous versus antesepalous ones, respectively. Other species for which the descriptions mention longer antesepalous than antepetalous stamens are *P. carolense* (Daly 1992) and *P. alvarezianum* (Daly & Fine 2011). The frequency, in *Protium*, of the stamen length relationship shown by *P. callianthum* is uncertain.

Tribe Protieae (the Protium Alliance per Daly et al. [2011]) is a well-supported clade in recent molecular analyses (Clarkson et al. 2002; Weeks et al. 2005; Thulin et al. 2008; Becerra et al. 2012; Fine et al. in review). It presently comprises the genera *Protium*, *Crepidospermum*, and *Tetragastris*, although the need for some taxonomic revision is often suggested (e.g. Thulin et al. 2008), and the latter 2 genera may soon have to be merged with *Protium* (P. Fine, pers. comm.). Relationships in the tribe were reviewed by Daly (1989), who offered criteria by which to distinguish among the 3 genera. Using his proposals, *P. callianthum* is separated from the small

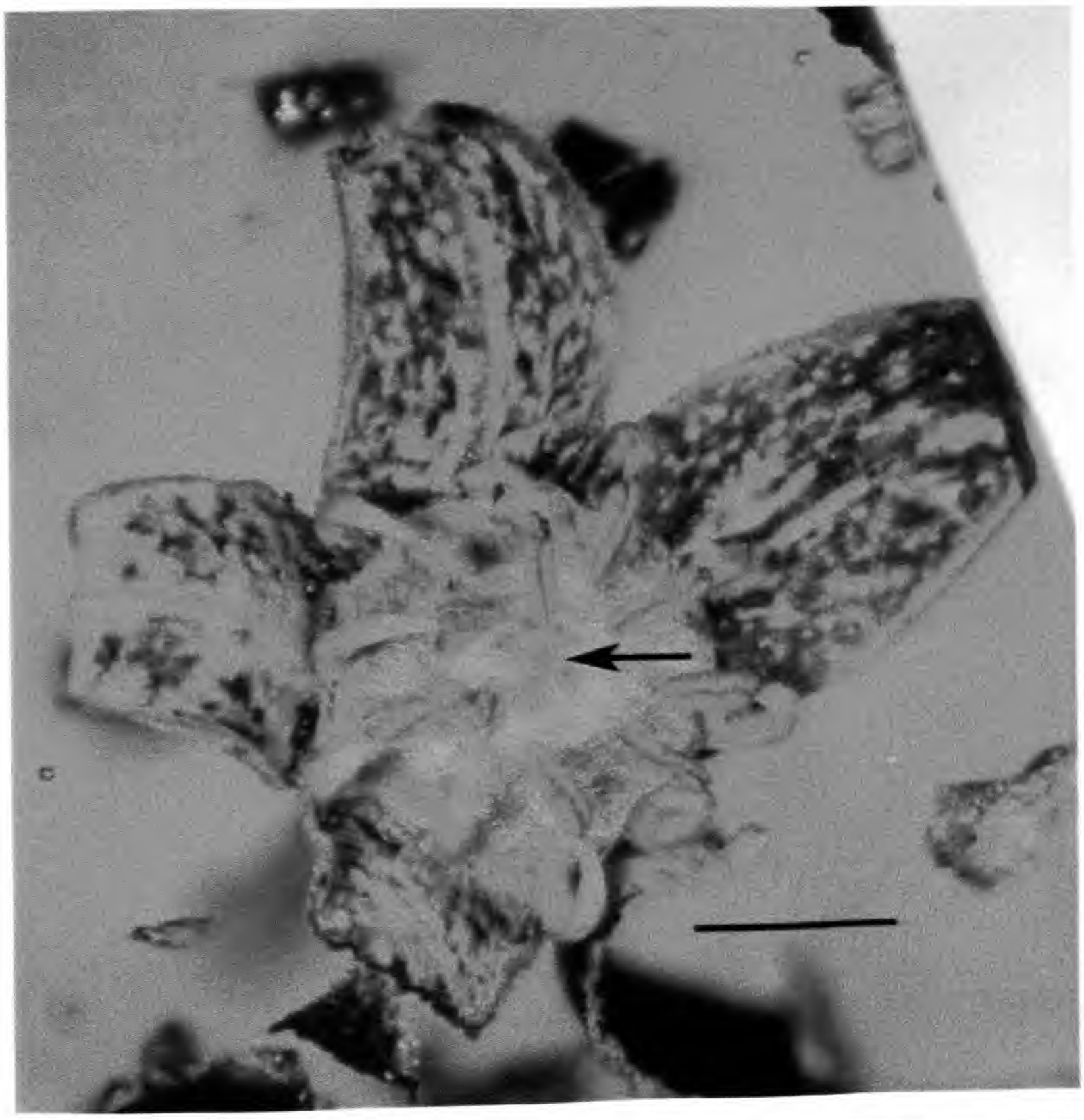


Fig. 1. *Protium callianthum*. Apical view of flower. Arrow indicates lobed stigma of pistillode. Scale bar = 0.80 mm.

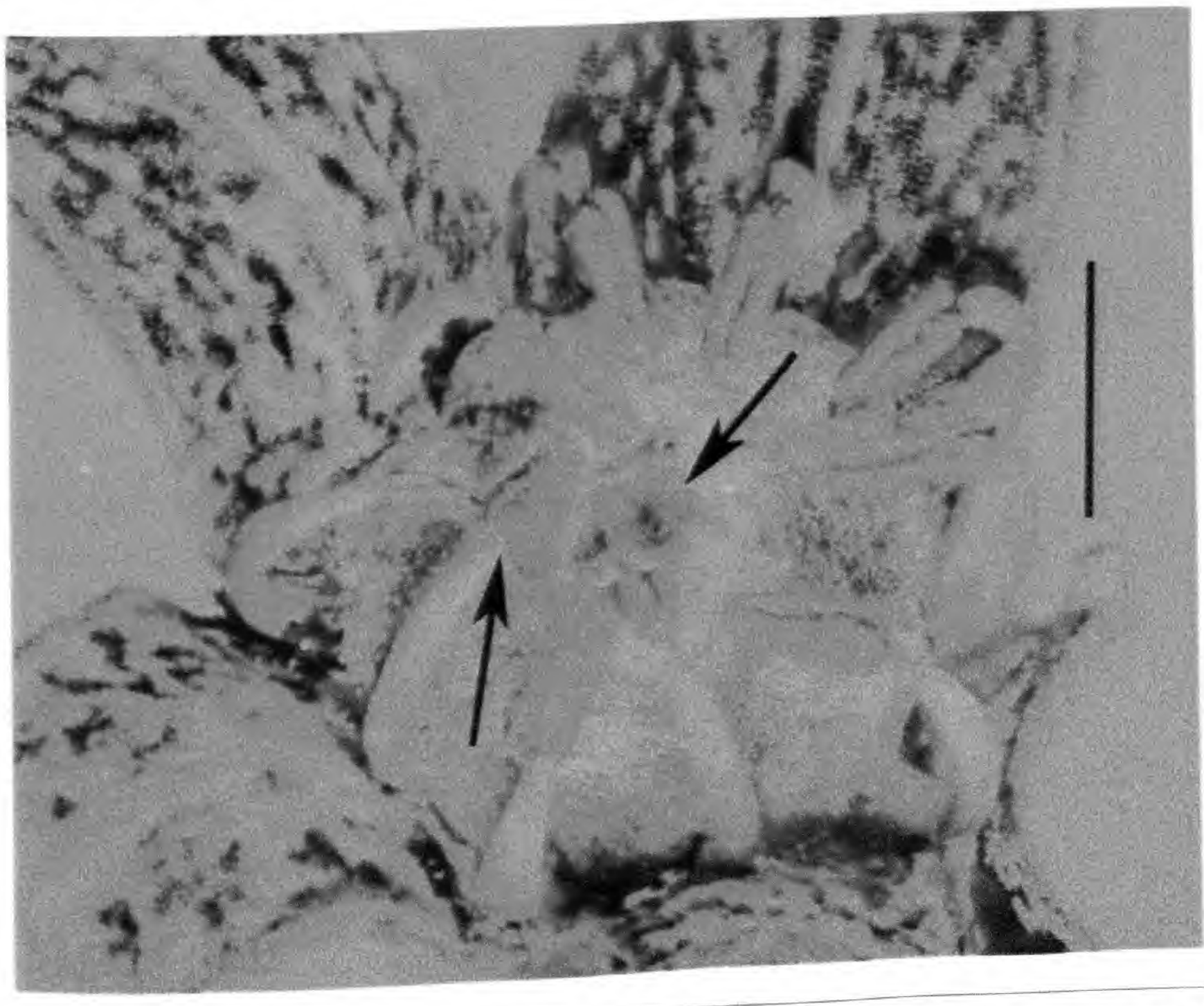


Fig. 2. *Protium callianthum*. Magnified apical view. Upper arrow is on lobed stigma, lower arrow shows basal insertion of anther on filament. Scale bar = 0.74 mm.

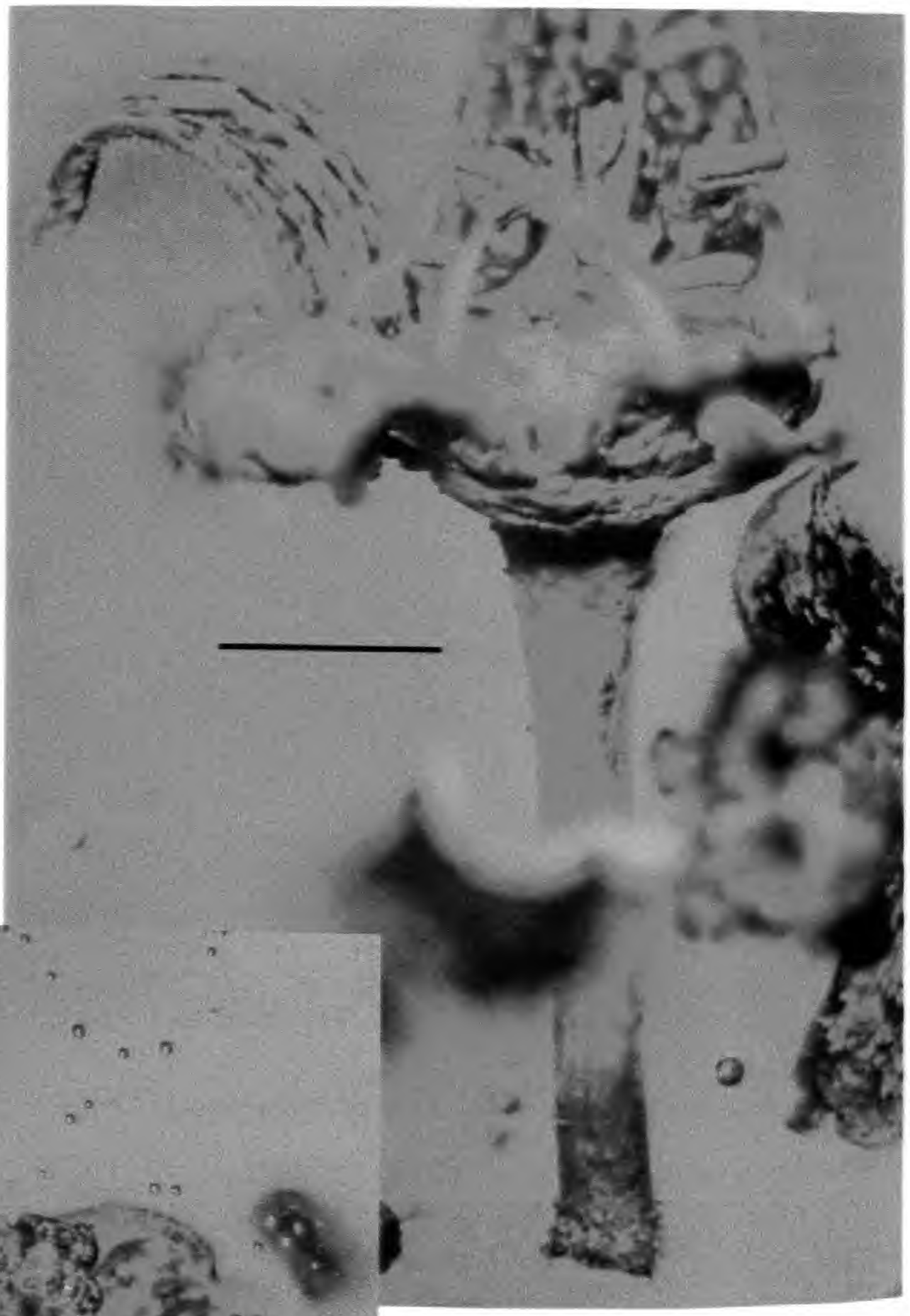


FIG. 3. *Protium callianthum*. Lateral view of flower and pedicel. Scale bar = 0.92 mm.

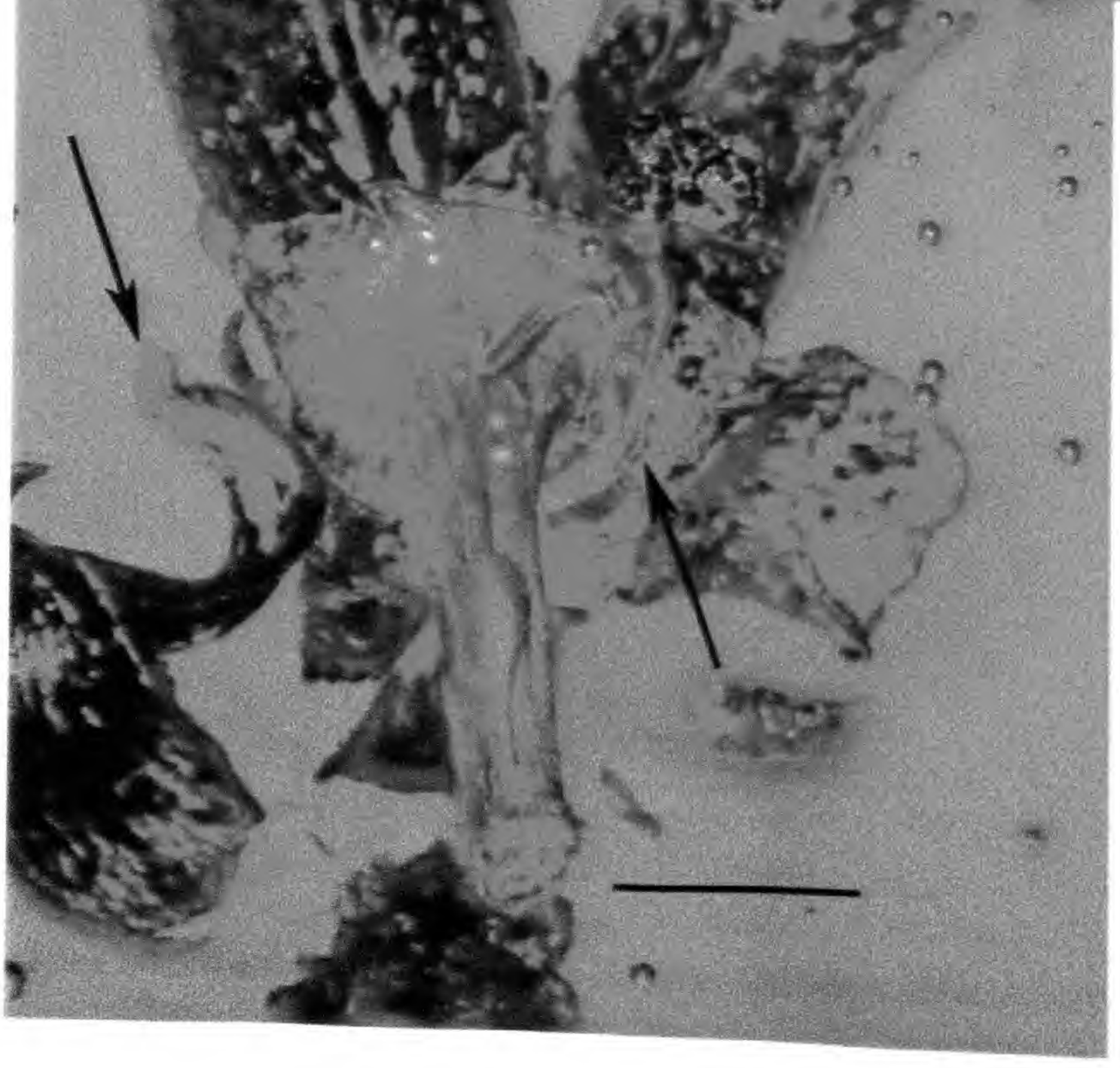


FIG. 4. *Protium callianthum*. Basal view of flower. Top arrow shows papillate margin of petal, left arrow is on inflexed petal tip of adjacent flower, lower arrow indicates calyx cup. Scale bar = 1.67 mm.

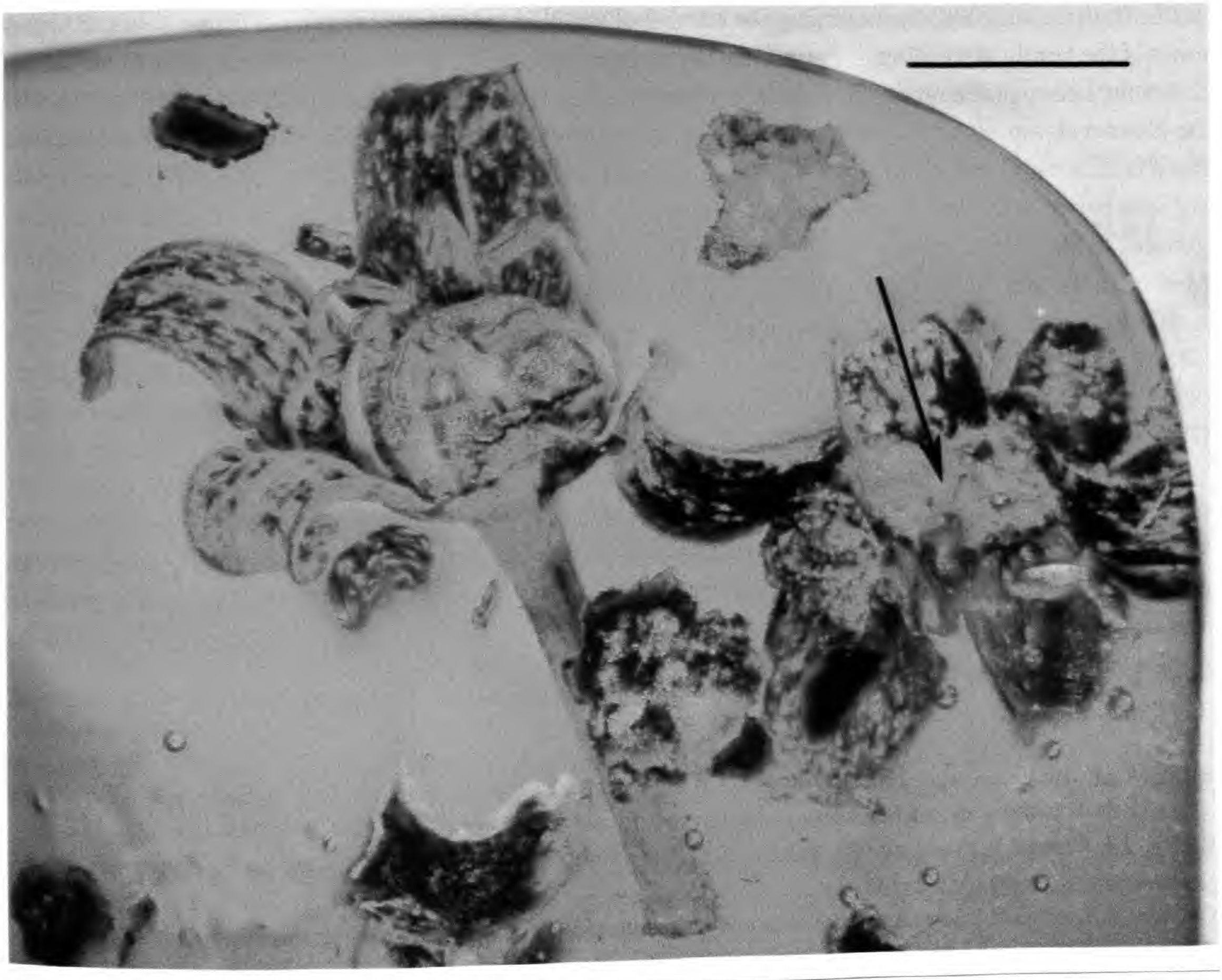


Fig. 5. *Protium callianthum*. Two adjacent flowers, the right one damaged by insect predation. Arrow is on partially eaten disc. Scale bar = 1.37 mm.

genus *Crepidospermum* by the lack of snail-shaped trichomes (Solereder 1908) on external organs. *Tetragastris* usually differs from *Protium* and from the fossil in having the anthers basifixed on short, broadly laminar filaments, the disc and pistillode fused into a conical "ovariodisc" in staminate flowers, and the petals partly connate (Daly 1989).

Following his description of *Protium carolense*, Daly (1992) mentions a relationship of this taxon with an insect that feeds on the flowers. He found that in a majority of collections, all the buds are infested with a larva, which eats the interior of the flower but does not prevent regular enlargement of the remaining perianth. Other collections of the species have developing fruits with no evidence of the infestation. In the block of amber containing the type fossil of *P. callianthum* is an adjacent staminate flower (Fig. 5) in which the stamens and top of the disc and pistil seem to have been eaten, quite possibly by an herbivorous insect of some kind. Whether the insect/flower relationship described for *P. carolense* might also have characterized *P. callianthum* is, of course, unknown, but it deserves mention for its possible botanical and entomological interest.

Protium callianthum is distinct from other taxa of the genus occurring today in the Caribbean region. One modern species of *Protium*, *P. glaucescens* Urb., is endemic to the Dominican Republic but differs from *P. callianthum* in its 4-merous, rather than 5-merous, flowers. The 5 species endemic to Cuba also have 4-merous flowers, while *P. attenuatum* (Rose) Urb. of the Lesser Antilles, with a 5-parted perianth, differs from *P. callianthum* in its ovate, dorsifixed anthers and 5-lobed stigma, among other floral traits.

The two most recent molecular phylogenetic studies of Burseraceae (Becerra et al. 2012; De-Nova et al. 2012), although emphasizing the genus *Bursera*, go beyond previous studies (Clarkson et al. 2002; Weeks et al.

2005; Thulin et al. 2008) by increasing the number of sampled species and proposing time-calibrated phylogenies of the family. According to the calculations of Becerra et al. (op. cit.), Burseraceae are over 92 Ma old, and the evolutionary proliferation of many modern genera occurred in the period of 30±10 Ma (their Fig. 3, p. 339). De-Nova et al. (op. cit.), however, give the age of the family's crown group as 64.92 (60.33-69.67) Ma and of the *Bursera* crown group as 49.43 (45.38-53.77) Ma. In a phylogenetic study of *Protium* by Fine et al. (under review), the split between this genus and *Bursera* is dated as ca. 52 Ma, and the diversification of the *Protium* clade begins ca. 20 Ma. The deposits of amber from the Dominican Republic are not precisely dated (see Materials and Methods), the youngest estimate being 20–15 Ma. The large clade to which *P. callianthum* probably belongs, containing, among others, the extant Caribbean species of *Protium*, diverged around 15 Ma, a figure that clearly would favor the younger of the 2 estimates for the age of the amber. *Protium callianthum* may be still older, on the stem of this clade, since it has no synapomorphies that match those in the larger, inclusive clade (P. Fine, pers. comm.).

ACKNOWLEDGMENTS

We thank David Harris for his taxonomic advice and Peter Endress for pointing us in the direction of an appropriate systematic placement for the fossil. Douglas Daly and Paul Fine provided valuable review comments and suggestions, as well as information from unpublished research. Alex Brown kindly made available the monographic treatise by Swart.

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BOOK REVIEW

STEVE MANNING. FOREWORD BY RUDOLF JENNY. 2010. **Discovering New World Orchids.** (ISBN: 978-0-9565594-0-1, hbk). Steve Manning, 4 The Cedars, Nantwich, Cheshire, CW5 5GZ, U.K. (**Orders:** Steve Manning, 4 The Cedars, Nantwich, Cheshire, CW5 5GZ, U.K.; orchidsmann@uwclub.net). £45 (approx. US $68.25), 669 pp., color throughout, 8 ¼" × 11 ⅝".

Rarely do we find such an exceptionally large, carefully researched and documented, beautifully illustrated botanical volume. Where else do you find a chapter titled "POLITICS, INTRIGUE, and JEALOUSY—The story of *Masdevallia uniflora*"?

Even the preliminary pages are fascinating:

- "Do you have any idea who Baron von Tueckleim was or have you ever heard of Mr. Falkenberg?" (Foreward, Rudolf Jenny)
- "It is from South America that we obtain the best orchids we have. There were many romances that might be related of the adventures experienced by collectors of Orchids." (Introduction, F.W. Moore, *Orchid Review*, June 1903:163)

By all means, read the Introduction first. In part: "The amateur enthusiasts who were willing to spend fortunes on orchids and other tropical plants were often subject to that green-eyed monster Envy—as were the traders who sought to out-do their rivals, and whose expertise was at times lacking." And "Yet not all professionals were incompetent, not all amateurs were self-centered and avaricious. There was much co-operation between amateurs and professionals, between traders and customers."

Each chapter is well written and contains excellent information. There are beautiful illustrations of plants, photos, early illustrations of settlements and mines and flowers, and often maps, comments, bits of history, etc.

This is an exceptional volume, with exquisite illustrations, and carefully documented information. It is also a fascinating, "can't put it down" read. Some readers might be a bit daunted by a large, 669-page volume, but it is absolutely beautifully presented, carefully researched, historically informational, and an astonishing floricultural history of the New World orchids.—*Helen Jeude, Volunteer and Assistant Editor, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.*

HIPPOCRATEA VOLUBILIS (CELASTRACEAE) IN COTUI COPAL FROM THE DOMINICAN REPUBLIC

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ABSTRACT

Four fossil flowers of *Hippocratea volubilis* were found preserved in copal from ground deposits near Cotui, Dominican Republic. The specimens fall within the pattern of morphological variation of this widespread New World species. The time of deposition of the copal is uncertain, the estimates ranging from under 1000 ybp to Miocene. The younger age is supported by carbon-14 dating from 2 laboratories, whereas the older date is based on measurements from proton magnetic resonance spectroscopy. Assignment of these fossils to a modern species supports an age of less than 1000 years for the Cotui deposits.

RESUMEN

Cuatro flores fósiles de *Hippocratea volubilis* se encontraron conservadas en copal en depósitos cerca de Cotui, República Dominicana. Los especimenes coinciden en su patrón de variación morfológica de esta especie frecuente del Nuevo Mundo. El tiempo de deposición del copal es incierto, las estimaciones varían desde por debajo de 1000 ybp hasta el Mioceno. La edad más reciente esta soportada por datación mediante carbono-14 en 2 laboratorios, mientras que la edad más antigua está basada en medidas de espectroscopía de resonancia magnética de protones. La asignación de estos tres fósiles a una especie moderna soporta una edad de menos de 1000 años para los depósitos de Cotui.

INTRODUCTION

Fossilized resin in the Dominican Republic occurs in a number of small mines in the northern and eastern portion of the country. The fossil material from these mines consists of amber and has been dated at 15–20 mybp using foraminifera index fossils (Itturalde-Vinent & MacPhee 1996) and at 20–45 mybp with coccolith index fossils (Cepek in Schlee 1990). Some softer, clearer material from the vicinity of Cotui has also been collected; however, the age of this is uncertain, although it has generally been considered younger than the amber. It is often referred to as "copal" or semi-fossilized resin, which differs from amber in a number of physical properties. Copal occurs in various parts of the world, especially in South America and New Zealand (Poinar 1992). It can be considered "young amber," and under the right conditions it could mature into amber after millions of years.

The flowers described here are members of the genus *Hippocratea* (Celastraceae, Hippocrateoideae), as defined by Smith (1940, p. 357). Three of the flowers are illustrated; the fourth is darkly pigmented and unsuitable for study. All are bisexual and in the pistillate phase, with stamens recurved and style elongated (Matthews & Endress 2005). The conical disc enclosing the pistil is divided horizontally into 2 sections and is minutely papillate throughout. The petals are imbricate at the base and abaxially tomentulose, with villous-ciliate margins. Pubescence of the adaxial surface consists of villous trichomes in a transverse band below the apex, equivalent to the "transversely barbellate" condition described by Smith (1940, p. 360) for *H. volubilis*. The sepals are ovate, imbricate, and minutely papillate abaxially. Based on comparison with a series of herbarium specimens of *H. volubilis* respecting these and other floral features, we identify the fossils as conspecific with this taxon.

Published estimates of the age of Cotui copal have ranged from Miocene to as young as 1000 ybp or less. Our conclusion that the *Hippocratea* flowers are assignable to the extant species *H. volubilis* strongly supports the latter, younger age, which was obtained from carbon-14 dating in 2 laboratories ("Beta Analytic" in the United States and "Harz aus dem Tennengebirge" in Germany).

Hippocratea pollen is well represented in the fossil record (Muller 1981), but to our knowledge these are the first fossil flowers of the genus to be discovered.

MATERIALS AND METHODS

The specimens were collected from the upper 8 inches of soil at Zambrana Abajo near Los Ranchos in the vicinity of Cotui, a village located in a valley between the Cordillera Central and Cordillera Septentrional, Dominican Republic. The material is clear with a yellow tinge. Many samples are collected by children who follow the plows during the planting of maize (personal correspondence from the late Jake Brodzinsky, 20 September 1987).

The age of fossilized resin from Cotui is unclear. Because of its light color and fairly soft texture, it has been referred to as copal, a term used for semi-fossilized resin that possesses specific physical properties related to color, hardness, melting point, and solubility (Poinar 1992). Age estimates range from under 1000 years, based on radiocarbon dating (Schlee 1984, Poinar, unpublished results), to Miocene, based on proton magnetic resonance spectroscopy (Lambert et al. 2012). In support of the older age was the discovery, in the copal, of several new insect species now considered to be extinct (Popov 1987; De Andrade & Baroni Urbani 1999).

Comparing the maturity of fossilized resins with that of their enclosing bedrock can provide information on the maturity, relative age, and biostratinomy of amber and copal. Such a study was conducted on amber and Cotui copal from different mines in the Dominican Republic (Poinar & Mastalerz 2000). Maturity of the bedrock was determined by vitrinite reflection and that of the fossilized resin by FTIR (Fourier Transform Infrared Analysis). The study found that Cotui copal showed a lower degree of maturity than that of the matrix rock, indicating that it had been washed into the older bedrock fairly recently and probably represents deltaic deposits. Further analysis of Cotui copal revealed that the plant source of the resin was *Hymenaea courbaril* (Mastalerz & Poinar, unpublished observations), a tree species that still exists on Hispaniola.

DESCRIPTION

Hippocratea volubilis L. (**Figs. 1–5**). Fossil specimens examined: HISPANIOLA. DOMINICAN REPUBLIC: vicinity of the town of Cotui, in a valley between Cordillera Central and Cordillera Septentrional, 2012, *unknown amber collector* (catalogue numbers Sd-9-105A, Sd-9-105B), and *J. Brodzinsky s.n.*, 1987 (Sd-9-105C), deposited in the Poinar amber collection maintained at Oregon State University, Corvallis, Oregon 97331, U.S.A.

Flowers bisexual, total length (pedicel apex to tip of style) 2.4 mm, calyx shallowly cupulate (Fig. 2), sepals 5, ovate, imbricate, 0.6–0.8 mm long, 0.8–0.9 mm wide, blunt-tipped, abaxially papillate, petals 5, spreading, lanceolate-elliptic, 2.1 mm long, 1.2 mm wide, 7–9-nerved, slightly overlapping at the base (Fig. 5), tip incurved, abaxial surface tomentulose with short, curved trichomes, adaxial surface with villous trichomes in a broad to narrow transverse band or arc slightly more than half-way distal from the base (Figs. 1, 4), sometimes papillate in a band proximal to the villous trichomes (Fig. 1), the central portion otherwise glabrous and distinctly veined downward to the base (Figs. 1, 4, 5), margins ciliate-villous (Figs. 1, 2), disc 1.3 mm high, 1.7 mm in diameter, pulvinate, conical, enclosing the ovary, 2-parted, enlarged below and above the mid-line (Figs. 1, 3), the surface densely and minutely papillate, stamens 3, strongly recurved (Figs. 1, 3, 4), filaments 0.5 mm long, 0.3 mm wide, strap-shaped, abaxially papillate near base (Fig. 1), anthers terminal, bilocular, ovoid, 0.4× 0.5 mm, dehiscent extrorsely by a single horizontal slit, exposed style 1.2 mm long, stigma minute, pedicel 1.5 mm long, puberulent.

DISCUSSION

For the purpose of comparison, we assumed that *Hippocratea volubilis*, which is widespread in Central and South America and the Caribbean region, is likely to be the extant species most closely related to the fossils.

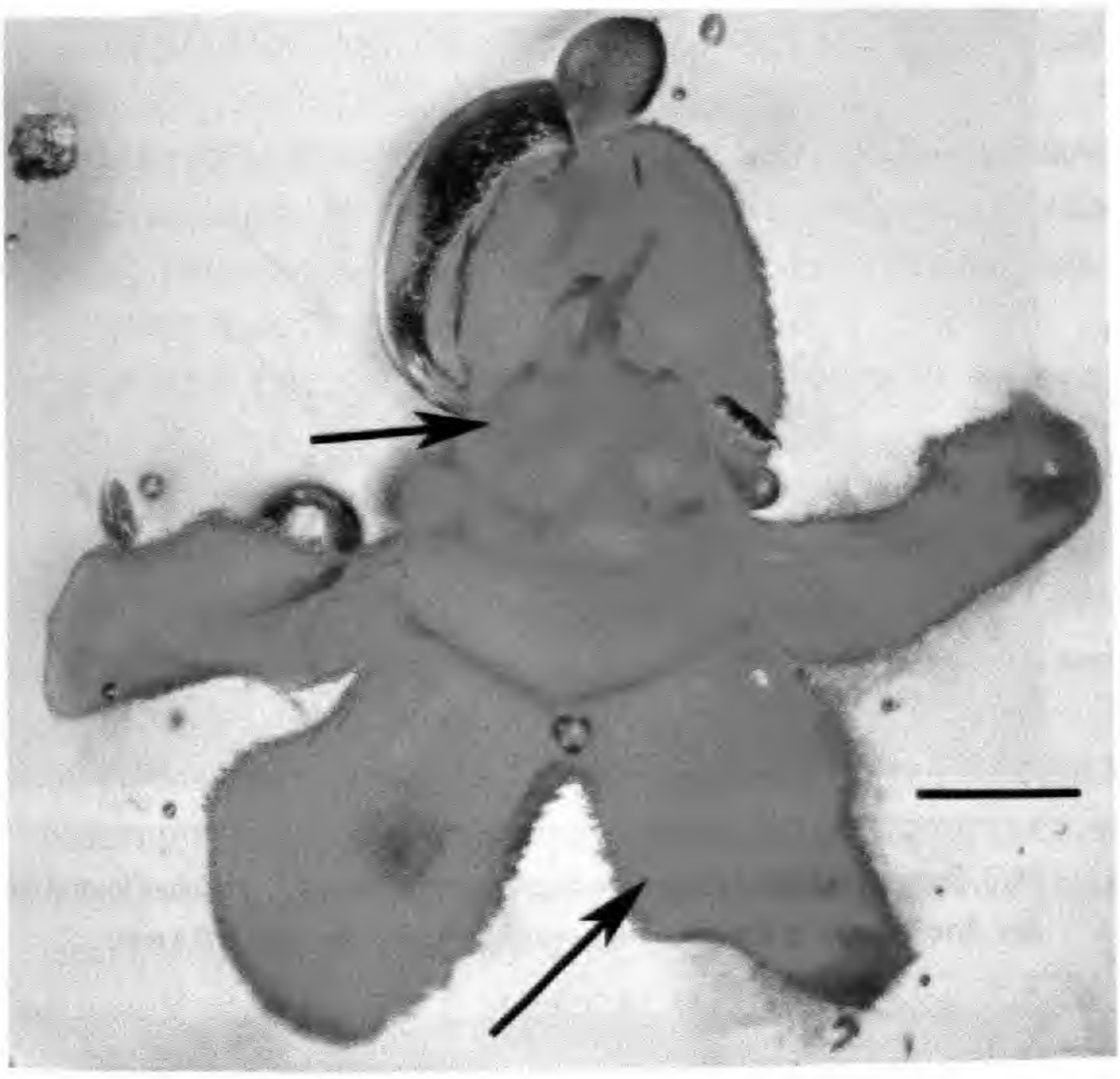


Fig. 1. Flower A, apical view, showing bilobed form of the disc. Note villous-ciliate margin and involute tip of petals. Short arrow points to abaxial papillae on filament. Long arrow designates band of papillate trichomes on adaxial petal surface. Bar = 1 mm.

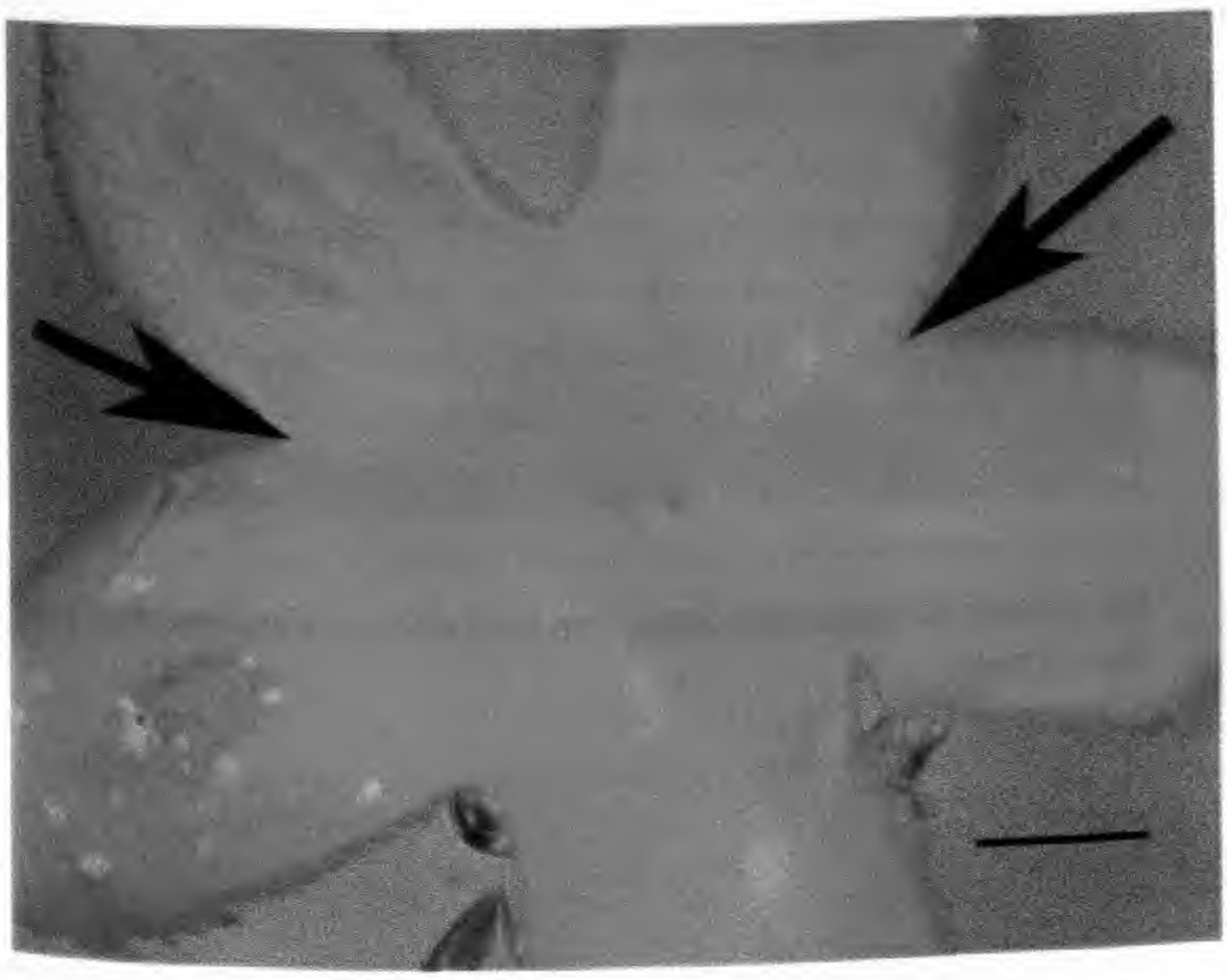


Fig. 2. Flower A in basal view, showing calyx and abaxial petal pubescence. Note villous-ciliate petal margins. Arrows point to 2 sepals alternating with petals. Bar = 0.6 mm.

The copal flowers are in the female stage of maturation, with reflexed stamens and elongated style, as illustrated by Matthews and Endress (2005, figs. 49, 50). The adaxial pubescence of the petals consists of a conspicuous band or arc of villous trichomes, which is essentially similar to the pubescence pattern in herbarium specimens of *H. volubilis*. Such trichomes were, in fact, cited by Smith (op. cit., p. 357) as a diagnostic trait of the genus. The petals of the flowers appear from photographs to be slightly connate, but careful microscopic study shows them to be basally imbricate. The floral disc is divided into upper and lower segments, thus differing from Smith's illustration of *H. volubilis* (op. cit., p. 357). However, similar 2-parted discs are often present in herbarium specimens of that species, including many from the Caribbean region. In *A. & P. Liogier* 30929, Puerto Rico (US2996525), for example, the upper and lower disc segments are sharply differentiated, with both parts being papillate, as in our fossils. In both *C.V. Morton 7839*, Honduras (US202361) and *R.S. & E.S. Howard 9817*, Dominican Republic (US2228804), on the other hand, the upper half of the disc is much more prominently papillate than the lower half. The upper section of the disc is sometimes reduced to a narrow papillate band below the anthers (e.g., *D.K. Christopher et al. 69*, NY s.n., Puerto Rico). A peculiarity of petal pubescence in both the modern and fossil flowers is that a zone of papillate trichomes may or may not be present proximal to the adaxial band of villous trichomes. This is illustrated in Fig. 1, although the microscopic nature of these papillae often makes them difficult to observe.

In the conservative taxonomic treatment by Smith (1940), *Hippocratea* was made monotypic, and over 40 existing specific and varietal names were synonymized under the single species *H. volubilis*. He limited this taxon to the tropics and subtropics of the New World, where its range extends north as far as the Everglades of Florida (Long & Lakela 1971). The pubescence of perianth, disc, androecium, and peduncle in the Cotui fossils, as described above, falls within the variation that we observed in available herbarium specimens of *H. volubilis*. With the exception of petal length and width, the sizes of floral parts in the fossils are within the ranges given for *H. volubilis* in Smith's species description (op. cit., p. 360). The petals are slightly shorter (2.1

vs. 2.5–4 mm) and narrower (1.2 vs. 1.3–2.6 mm) than measurements cited by Smith for the extant species. There is no indication that these quantitative differences are due to the process of preservation.

The assignment of the flowers to an extant species favors the more recent of the two conflicting age estimates for Cotui copal, namely an age of 1000 years or less, commensurate with the results from carbon-14 dating.

Hippocratea and its allied genera, once recognized as the separate family Hippocrateaceae (Smith 1940; Loesener 1942; Long & Lakela 1971; and others), are now included in family Celastraceae as subfamily Hippocrateoideae (Simmons 2004, Matthews & Endress 2005, Stevens 2001 onwards). Molecular phylogenetic studies by Savolainen et al. (1997, 2000), Simmons et al. (2001a, 2001b), and others confirm this relationship. The subfamily has been shown to comprise a monophyletic group (Simmons et al. 2001b, Simmons 2004), but the tribe Hippocrateeae, to which the genus is assigned, is not monophyletic unless tribe Campylostemoneae is included (Simmons et al. 2001b).

The described specimens appear to be the first recorded sub-fossil flowers of the genus. They will be useful to future monographers, floristics workers, and paleontologists interested in the Caribbean region. As noted above, there are pollen records of *Hippocratea* from the Oligocene and lower Miocene (Muller 1981, p. 81).

ACKNOWLEDGMENTS

We are grateful to Peter Endress for pointing us to the correct identification of the fossil. Helpful review comments by Mark Simmons and Peter Endress are acknowledged with thanks. Herbarium specimens were kindly lent for our study by the Missouri Botanical Garden, the New York Botanical Garden, and the United States National Herbarium.

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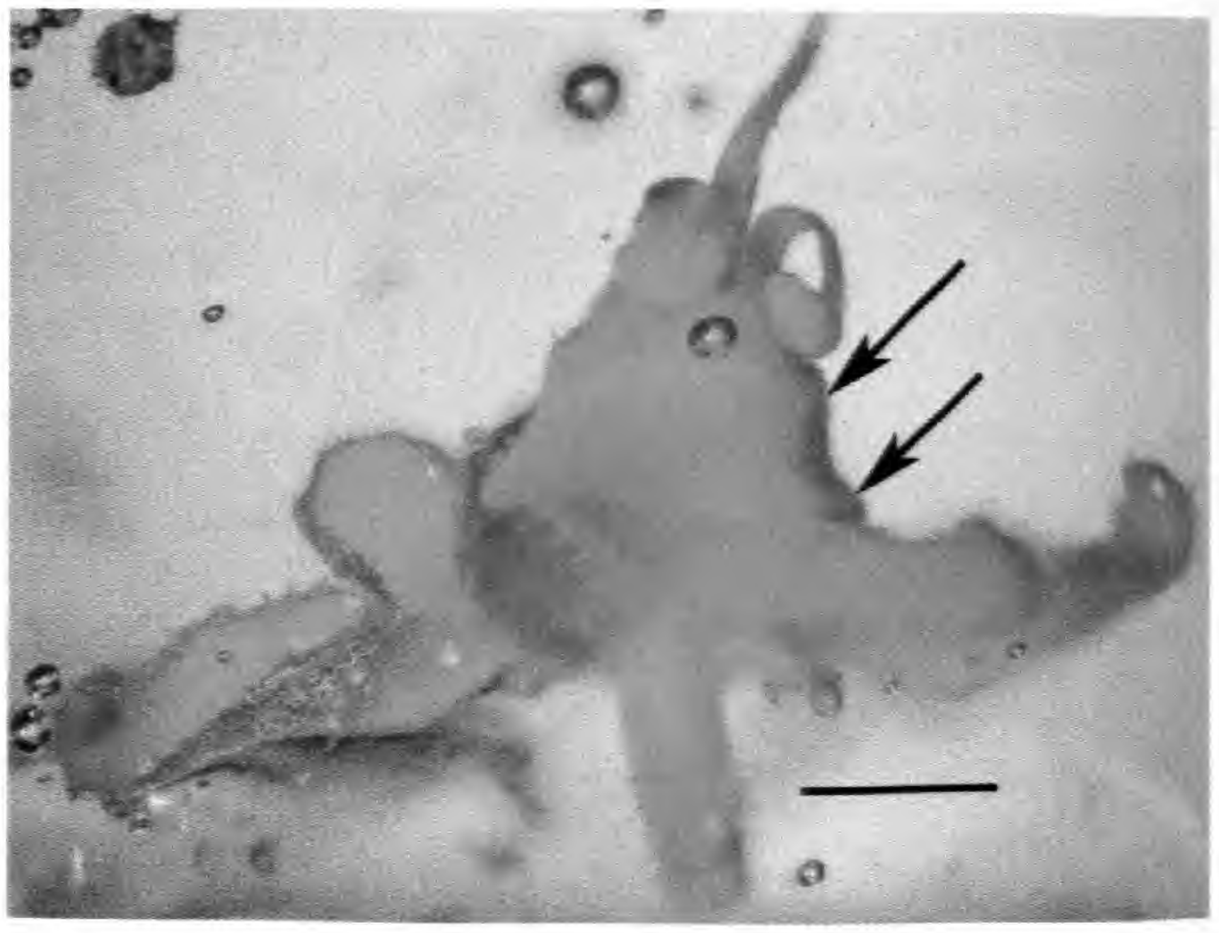


Fig. 3. Flower A in lateral view, showing reflexed stamens and bilobed form of the disc. Arrows point to 2 zones of enlargement of the disc. Bar = 0.8 mm.

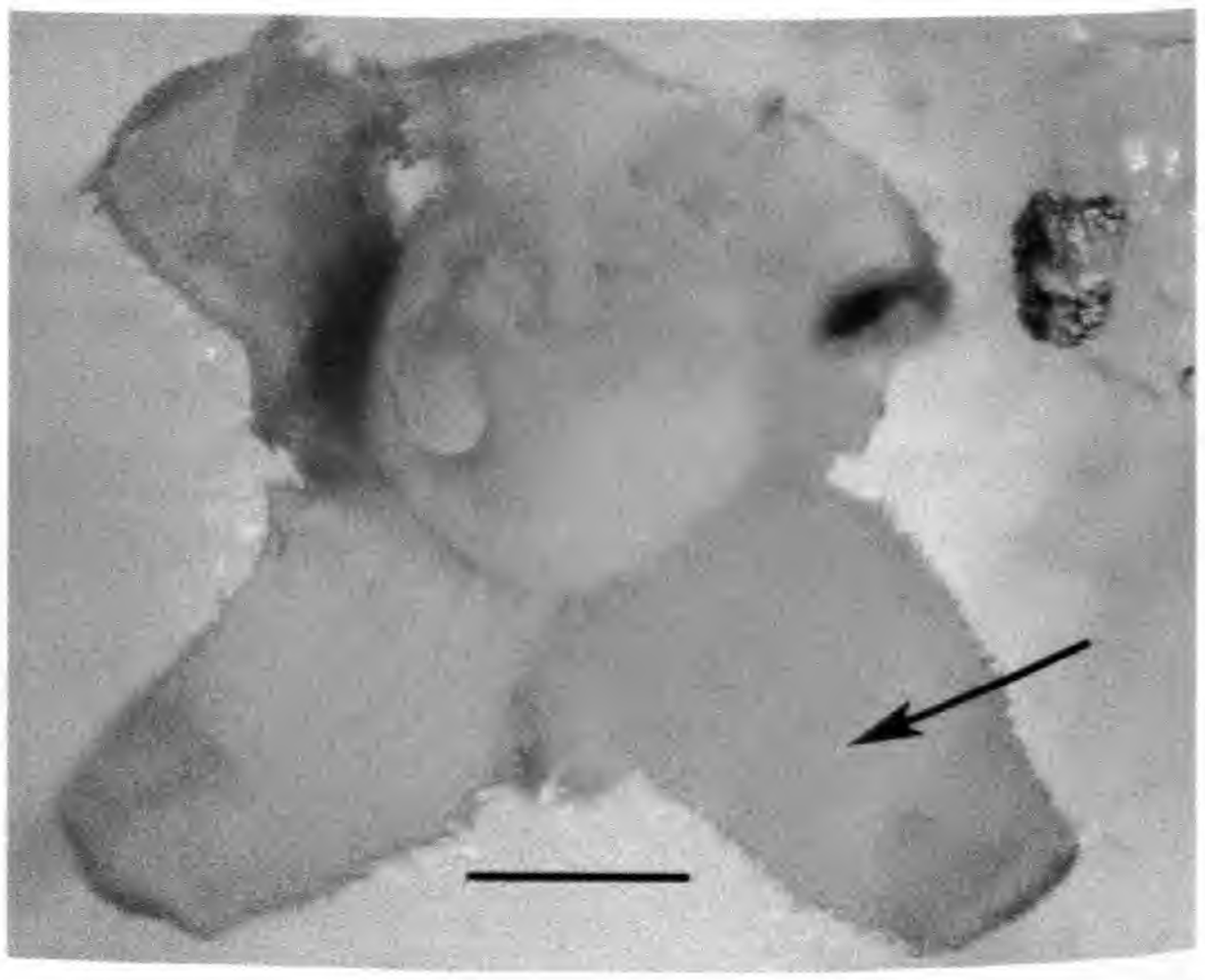


Fig. 4. Flower B in apical view. Arrow is on band of villous trichomes across petal. Bar = 0.8 mm.

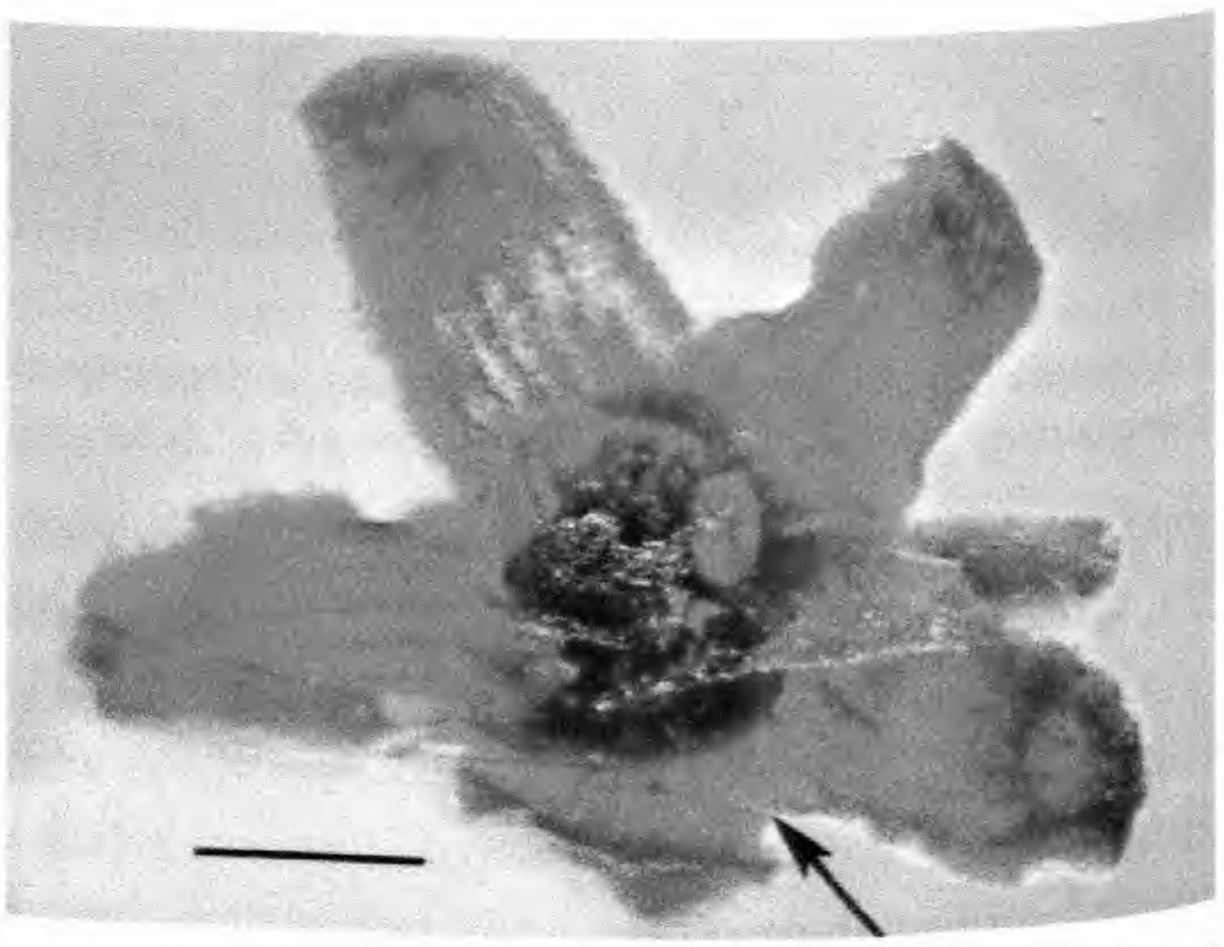


Fig. 5. Flower C, with center damaged in the process of polishing the amber. Arrow shows short region of petal overlap at the base. Bar = 0.8 mm.

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BOOK NOTICE

Elizabeth Findley Shores. 2010. **On Harper's Trail: Roland McMillan Harper, Pioneering Botanist of the Southern Coastal Plain.** (ISBN: 978-0-8203-3100-3, cloth). The University of Georgia Press, 4435 Atlanta Highway, Athens, Georgia 30602, U.S.A. (**Orders:** www.ugapress.org, 1-800-266-5842, 1-706-425-3061 fax). $44.95 hbk, $24.95 pbk, 296 pp., 20 b/w photos, 1 illus., 1 map, bib., index, 6" × 9".

From the publisher: "Roland McMillan Harper (1878–1966) had perhaps 'the greatest store of field experience of any living botanist of the Southeast,' according to Bassett Maguire, the renowned plant scientist of the New York Botanical Garden. However, Harper's scientific contributions, including his pioneering work on the ecological importance of wetlands and fire, were buried for decades in the enormous collection of photographs and documents he left. In addition, Harper's reputation as a scientist has often been obscured by his reputation as an eccentric. With this book, Elizabeth Findley Shores provides the first full-length biography of the accomplished botanist, documentary photographer, and explorer of the southern coastal plain's wilderness areas.

Incorporating a wealth of detail about Harper's interests, accomplishments, and influences, Shores follows his entire scientific career, which was anchored by a thirty-five-year stint with the Alabama Geological Survey. Shores looks at Harper's collaboration with his brother Francis, as they traced William Bartram's route through Alabama and the Florida panhandle and as Francis edited the Naturalist Edition of *The Travels of William Bartram*. She reveals Roland's acquaintance with some of the most important, and sometimes controversial, scientists of his day, including Nathaniel Britton, Hugo de Vries, and Charles Davenport. Shores also explores Harper's personal relationships and the cluster of personality traits that sparked his interest in genetic predestination and other concepts of the eugenics movement.

Roland Harper described dozens of plant species and varieties, published hundreds of scientific papers, and made notable contributions to geography and geology. In addition to explaining Harper's eminence among southeastern naturalists, this story spans fundamental shifts in the biological sciences—from an emphasis on field observation to a new focus on life at the molecular level, and from the dawn of evolutionary theory to the modern synthesis to sociobiology."

Elizabeth Findley Shores is a writer and native of Tuscaloosa, Alabama. She holds degrees in history from Boston University and the University of Arkansas, Little Rock.

KARYOTYPES OF *MUHLENBERGIA RIGIDA* (POACEAE: CHLORIDOIDEAE) FROM NORTH CENTRAL MEXICO

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ABSTRACT

Karyotypes from two morphotypes in 30 populations of *Muhlenbergia rigida* (Kunth) Trin. from locations in six states in north central Mexico were analyzed. The basic ploidy ($x = 10$), tetraploidy ($n = 40$) and disploidy ($n = 44$) reported previously for the species are confirmed, and triploidy ($n = 30$) is reported for the first time in 13 of the 30 populations studied. Analysis of karyotypes reveal a correlation among cytotypes and morphotypes of *M. rigida*. Triploid cytotypes correspond to the morphotype having open inflorescences whereas tetraploid and disploid plants correspond to the morphotype with dense inflorescences.

KEY WORDS: grasses, karyology, *Muhlenbergia rigida*, ploidy level

RESUMEN

Se presentan los cariotipos de dos morfotipos en 30 poblaciones de *Muhlenbergia rigida* (Kunth) Trin. provenientes de localidades en seis estados del norte-centro de México. Se confirma el número básico ($x = 10$), tetraploidía ($n = 40$) y disploidía ($n = 44$) reportados anteriormente para la especie, y se registra por primera vez triploidía ($n = 30$), en 13 de las 30 poblaciones estudiadas. El análisis de los cariotipos revela una correlación entre los citotipos y los morfotipos de *M. rigida*, con los citotipos triploides relacionados con el morfotipo de inflorescencia abierta, mientras que los tetraploides y disploides corresponden al morfotipo de inflorescencia densa.

PALABRAS CLAVE: cariología, gramíneas, *Muhlenbergia rigida*, nivel de ploidía

INTRODUCTION

Muhlenbergia is one of the largest genera of the Poaceae family, with approximately 160 species worldwide. Of those, 150 are distributed mainly in the temperate forests and grasslands located on the American continent; only six species are endemic to South Asia (Clayton & Renvoize 1986; Peterson 2000; Peterson & Annable 1991; Peterson & Ortíz-Díaz 1998; Peterson and Herrera 2001; Watson & Dallwitz 1992). There are around 133 species of *Muhlenbergia* native to the Southern United States of America and Northern Mexico, some of them even reaching Central America (38) and South America (25). The majority of the species (120) are located in Mexico (Beetle 1986; Espejo-Serna et al. 2000; Espejo Serna 2012; Herrera Arrieta 1987, 1998; Herrera Arrieta & de la Cerda Lemus 1995; Herrera Arrieta & Peterson 1992; Peterson et al. 2001; Peterson 2003; Peterson & Valdés-Reyna 1999). *Muhlenbergia* is a genus with great morphological variation, especially within vegetative characters, ranging from very small plants (5 to 40 cm tall) in *M. minutissima* (Steud.) Swallen to very large ones (150–300 cm tall) in *M. robusta* (E. Fourn.) Hitchc. Furthermore, *M. rigida* (Kunth) Trin. has populations

that differ in plant habit as well as in the shape and size of their inflorescence, which can be compact (dense) or loose (open), large or small. This creates taxonomic confusion and problems with the specific delimitation.

Few chromosome studies have been carried out on the genus *Muhlenbergia*. Soderstrom (1967) stated that Avdulov (1931) was the first who reported cytological information as a basis for a new classification system of Poaceae. Although Sodertstrom (op. cit.) did not carry out cytological studies, he does mention the results from several studies which reported a base chromosome number for *Muhlenbergia* of $x = 9$, 10, or 21. These studies included the $2n$ chromosome number for the species of sect. *Epicampes*. Peterson (1988) studied the chromosome number of 25 annual *Muhlenbergia* species, reporting for the first time the chromosome number of nine of them. Noteworthy among these are *Muhlenbergia biloba* Hitchc. and *M. shepherdii* (Vasey) Swallen since they are $n = 8$. Herrera (1995) published the chromosome number of three species of the *M. montana* (Nutt.) Hitchc. complex [(*M. montana, M. quadridentata* (Kunth) Trin., and *M. virescens* (Kunth) Trin.)], recording for the first time the chromosome number of *M. quadridentata*, the disploid chromosome number of *M. virescens* and confirming the tetraploid condition of *M. montana*. Gould (1966) carried out karyotyping of 60 genera and 149 species of Mexican grasses, eight of which belong to *Muhlenbergia*. However, *M. rigida* was not included in Gould's study.

Muhlenbergia rigida is a grass with widespread distribution in the SW United States and ranges south to Central and South America. In Mexico it is found from Baja California to Chiapas. The grass can be found growing in pine-oak forests and grasslands, sporadically at the edge of roads, and at elevations between 1280–2550 m (Herrera Arrieta & Peterson 2007).

This capacity to grow in such extensive areas with diverse habitats translates into a great morphological diversity within the species (rigida). This diversity of traits is reflected mainly in the shape and size of leaves and inflorescences, with variation among the type of inflorescence (compact or loose) being particularly notorious. However, there is no correlation between morphotypes and habitats or geographical distribution as frequently both morphotypes can be found growing in the same location. On the basis of the great morphological variation of *M. rigida* and the complementary information that is generated in an inter-population cytogenetic study, the aim of the present study is to compare the karyotype of two morphotypes in 30 populations of *M. rigida* located in north central Mexico. This comparison will reveal any relationship between the karyotype and the morphological differences within the species as well as other relevant variations that allow the distinction of groups among the studied populations, or otherwise distinguish between the two morphotypes.

MATERIALS AND METHODS

Plant material

Sample material was collected from 27 locations (Fig. 1) and 30 populations of *Muhlenbergia rigida*, following its distribution in the states of Chihuahua, Durango, Zacatecas, Aguascalientes, Guanajuato, and Jalisco, Mexico (Table 1). Live plants were collected (bunches) from natural populations and cultivated under greenhouse conditions in order to collect the roots required for this study. Table 1 lists the voucher, disploid number, and localities (including geographical coordinates and elevation) in which the studied plants were collected.

Karyotyping

Karyotypes were studied using roots obtained from adult plants cultivated in the greenhouse. When roots reached approximately 1–1.5 cm in length, they were subjected to a treatment with an 8-hidroxiquinolein (2 mM) solution in darkness for 3 hours at room temperature. Later they were fixed with ethanol/acetic acid (3:1) for 12 hours at 4°C, followed by hydrolysis with three passes using distilled water at 30-minute intervals, and then acid hydrolysis using 0.1N HCl, and citrates buffer for 30 minutes, then a final digestion using a 4% cellulase enzyme mixture "Onozuka R-10 (Serva)" and 1% pectinase Y-23 (Seishin Pharmaceutical) for 1 hour at 37°C. After a quick wash using distilled water, roots were kept for one minute in 45% acetic acid followed by the corresponding squashing. Cover slides were removed after the samples were kept at -84°C. Preparations were left to dry for 1 day at ambient temperature. Chromosomes were stained using the acetocarmine reagent. Counting, analysis, and interpretation of the chromosomes (in 7–10 metaphase slides) was carried out using an

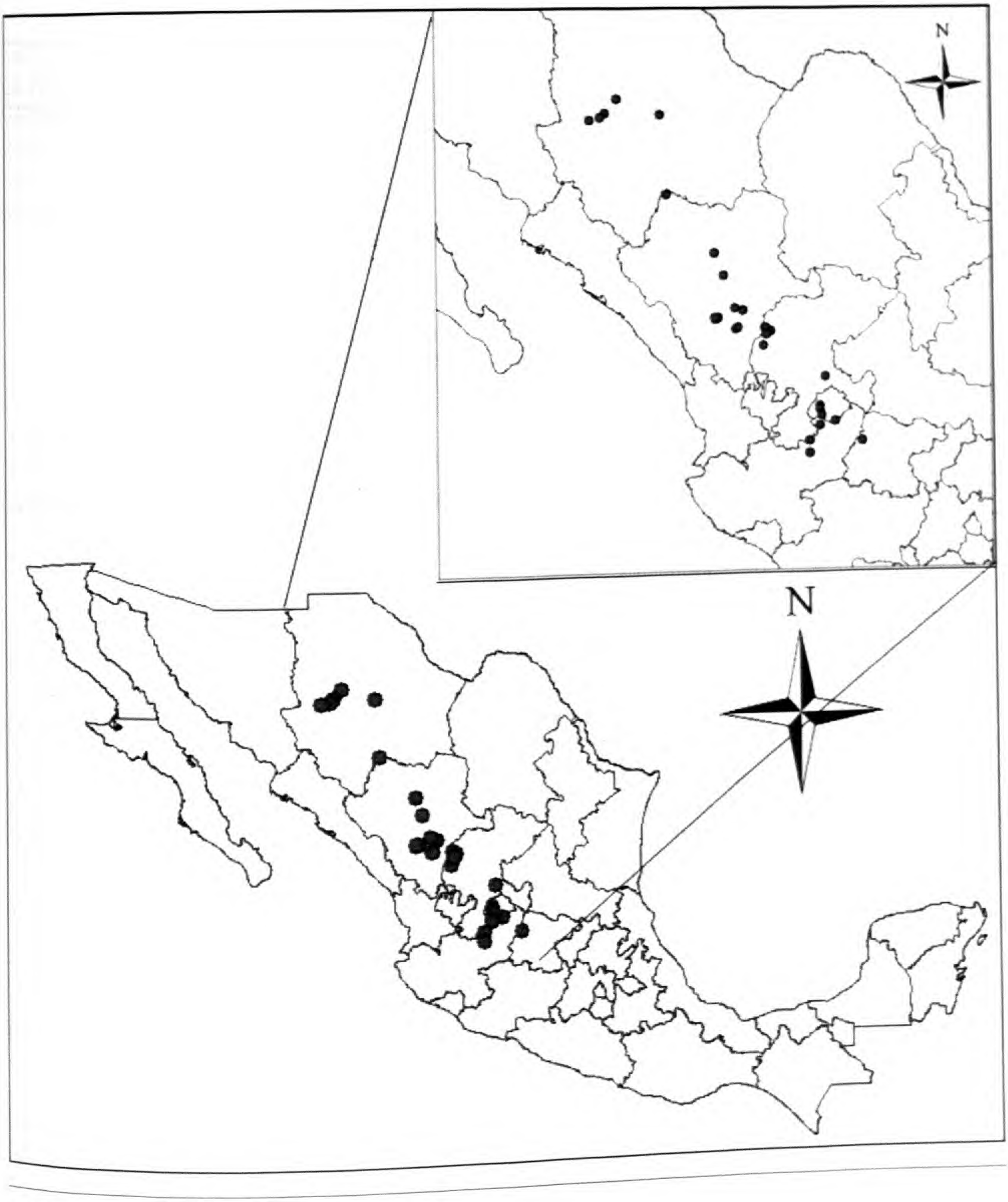


Fig. 1. Map showing the collection localities of *Muhlenbergia rigida*.

Axioskop Zeiss microscope fitted with digital camera. The MicroMeasure software http://www.colostate.edu/Depts/Biology/MicroMeasure) was used for measuring the length of each chromosome.

The ratio of the chromosome arms (r) (long arm: short arm) was also calculated, while the nomenclature used for describing chromosome morphology was that proposed by Levan et al. (1964): m = metacentric (r: 1.00–1.69), sm = submetacentric (r = 1.70–2.99), and st = subtelocentric (r = 3.00–6.99). Stebbins' standardization (1938) was used for classifying chromosomes according to their length: <2 µm, small; 2–4.9 µm, medium-small; 5–9 µm, medium-large; >9 µm, large.

In order to carry out the quantitative characterization of the karyotypes the following parameters were

Table 1. *Muhlenbergia rigida* populations with karyotype studies.

Population	2n	Locality
O. Rosales 3970	40	5.3 km Al NW de La Hacienda La Pila, Dgo., 24°07'44.8"N y 104°18'29.3"W, 1884 m
O. Rosales 3976	40	Rancho Los Yugos, San José de Gracia, Ags., 22°00'00.2"N y 102°34'38.8"W, 2369 m
O. Rosales 3982	40	3.3 km al W de La Parrilla, Dgo., 23°43'39.6"N y 104°28'22.92.2ºW, 2260 m
O. Rosales 3990	30	2.7 km. del entronque carretera federal libre 40 hacia la carretera federal de cuota 40, Durango, Dgo. 23°56'55.7"N y 104°56'15.3"W, 2415 m
O. Rosales 3993	30	Puente Río Chico, carretera de cuota Durango-Mazatlán, Durango, Dgo.23°58'38.0"N y 104°53'32.5"W, 2256 m
O. Rosales 4016	44	1 km del entronque Jiménez del Teul hacia Molina de Agua Zarca, Jiménez del Teul, Zac. 23°21'00.01"N y 103°51'10.2"W, 2271 m
O. Rosales 4028	30	Km 168 carretera Sombrerete-Durango, Sombrerete, Zac. 23°39'52.7"N y 103°40'23.1"W, 2425 m
O. Rosales 4029	30	Sierra de Órganos, Sombrerete, Zac., 23°44'38.7"N y 103°48'22.3"W, 2296 m
O. Rosales 4030	40	Sierra de Órganos, Sombrerete, Zac. 23°44'39.6"N y 103°48'02.0"W, 2329 m
O. Rosales 4053	30	Sierra del Registro por carretera federal 23, Durango, Dgo. 23°45'51.6"N y 104°25'29"W, 2014 m
O. Rosales 4098	44	Parte alta de la Cañada el Cajón, Santa María, El Oro, Durango, 25°24'42.8"N y 104°57'28.4"W, 1914 m
O. Rosales 4124	40	Entronque Otinapa-Autopista Durango-Mazatlán, Durango, Dgo. 23°58'35.0"N y 104°56'59.7"W, 2446 m
O. Rosales 4140	40	Km 25 Autopista Durango-Torreón, Durango, Dgo. 24°11'12.0"N y104°29'31.7"W, 1864 m
O. Rosales 4146	30	Por la carretera 105, rumbo a la presa Bayacora, Durango, Dgo., 34°54'44.1"N y 104°44'46.9"W, 2185 m
O. Rosales 4158	30	Cerro de Los Gallos, Aguascalientes, Ags. 21°40'03.6"N y 102°13'15.8"W, 2191 m
O. Rosales 4159	40	Cerro de Los Gallos, Aguascalientes, Ags. 21°40'03.6"N y 102°13'15.8"W, 2191 m
O. Rosales 4162	40	Entronque a Milpillas, Jesús María, Ags. 21°55'28.6"N y 102°33'57.7"W, 2186 m
O. Rosales 4166	30	Cerro El Roble, Jesús María, Ags., 21°47'30.7"N y 102°31'26.3"W, 2019 m
O. Rosales 4170	40	6 km antes de la caseta de cobro por la autopista Aguascalientes-Zacatecas, Guadalupe, Zac., 22°39'19.6"N y 102°26'45.5"W, 2305 m
O. Rosales 4177	44	1.5 km al SE de Canutillo, Sombrerete, Zac. 23°35'26.0"N y 103°46'22.0"W, 2119 m
O. Rosales 4187	30	Carretera 24 rumbo hacia Guadalupe y Calvo, Chih. 26°42'27.2"N y 106°04'15.9" W, 2296 m
O. Rosales 4202	30	Carretera Chihuahua-Cuauhtémoc, Chih. 28°28'04.3" y 106°11'50.7"W, 1711 m
O. Rosales 4203	30	Al sur la ciudad de Guerrero, Guerrero, Chih. 28°30'15.8"N y 107°29'00.3"W, 2045 m
O. Rosales 4210	30	Carretera 16 Yecoma-Cuauhtémoc, Chih. 28°24'09.4"N y 107°34'57.0"W, 2277 m
O. Rosales 4215	40	Carretera 16 Yecoma-Cuauhtémoc, al norte de Temochi, Chih., 28°21'20.7"N y107°49'26.0"W, 2075 m
O. Rosales 4219	40	Limites Cd. Cuauhtémoc-Bachiniva, Chih. 28°48'34.6"N y 107°11'59"W, 2260 m
O. Rosales 4227	40	Entronque al Soyatal por carretera Villa Hidalgo- Teocaltiche, Jal. 21°34'55.6"N y 102°34'26.4"W, 1910 m
O. Rosales 4234	30	Carretera Nochistlan-Yahualica, Yahualica, Jal. 21°14'46.3"N y 102°48'53.4"W, 1798 m
O. Rosales 4235	44	Km 25 carretera Yahualica-Jalostotitlan, entronque a Mezcala de los Romero, Jal. 20°57'44.0"N y 102°48'57.8"W, 1820 m
O. Rosales 4252	30	Sierra de Lobos por carretera Ocampo-León, Gto. 21°13'24.7"N y 101°36'40.3"W, 2544 m

calculated: (1) total chromosome length (LTC); (2) mean chromosome length (LMC); (3) centromere index mean (short arm/total chromosome length x 100 [CI]); (4) intra-chromosomal asymmetry index (A1) = 1-[Σ(*b/B/n*), where *b* and *B* are the measures of the short and long arm of each homologous chromosome pair respectively and *n* is the total number of homologues; (5) inter-chromosomal asymmetry index (A2) = *s/x*, where *s* is the standard deviation and *x* is the mean chromosome length; (6) Paszko Index AI = CVCL x CVCI/100 where CVCL= (SCL/XCL) x 100 is the relative variation of chromosome length, CVCI = (SCI/XCI) x 100 is the relative variation of the centromere length, respectively, XCL is the mean chromosome length and XCI is the CI mean. Karyotype asymmetry was determined using Stebbins' categories (1971), A1 and A2 indices (Romero-Zarco 1986) and the AI index (Paszko 2006). The A1 index is a quantification of Stebbins' asymmetry categories. It ranges between 0 and 1, and these are low when chromosomes tend to be metacentric. Basic interpretation of AI values determines that the higher the value, the higher is the heterogeneity of chromosome length and/or the centromere index in a studied karyotype (García-Barriuso et al. 2010).

In the ideograms, homologue chromosome pairs were ordered according to their length in decreasing-size order. Four to seven metaphase cells were measured from various slides in order to obtain an average for construction of the ideograms. Measurements were compared using ANOVA. The TCL, CI, A1 and A2 indices as well as chromosome number were considered.

Clustering analysis of the karyotype data was carried out in order to examine karyotype similitude among populations. A data matrix of 30 OTUs (operational taxonomic units) and five variables was constructed. The following variables were used: LMC, CI, A1, A2 and chromosome number. The first four variables were used because they are not influenced by chromosome number. Nevertheless, ploidy level was also used since different characteristics of various populations of *Muhlenbergia rigida* morphotypes are being compared. The STATISTICA v.7.0 (StatSoft, 2004) software package was used to normalize the data matrix, calculate the average Euclidean distance, and generate an UPGMA dendrogram.

Also, in order to evaluate the contribution of each karyotype parameter to the population clustering, the entities were subject to a principal component analysis (PCA) based on the 30 OTU data matrix and the aforementioned five quantitative variables.

RESULTS

The chromosome counts obtained from radicular cells of *Muhlenbergia rigida* in this study are consistent with the numbers reported by Herrera and Peterson (2007) and Soderstrom (1967), both of which documented $2n$ = 40 and 44. This study recorded $2n$ = 30, 40, and 44; marking the first report of triploidy in this species. It is noteworthy to mention that the $2n$ = 40 and $2n$ = 44 counts were found in the compact panicle morphotype while the $2n$ = 30 count was present in the open panicle morphotype.

Our results support previous suggestions that the basic number of *Muhlenbergia* is x = 10, with $2n$ = 40 occurring in the majority of the species. Polyploidy is equally distributed in the morphotypes of *M. rigida* studied here: 43.33% of the plants are tetraploid ($2n$ = 4x = 40), 43.33% are triploid ($2n$ = 3x = 30) and only 13.33% are disploid, derived from tetraploid ($2n$ = 4x + 4).

We report for the first time the karyotype formula of 30 chromosomes in *M. rigida* populations as well as the ideograms representing the three ploidy levels found (Fig. 2)

As a whole, the karyotypes of the species analyzed were composed of metacentric (m) and submetacentric (sm) chromosomes, with the former being predominant. The formulae among triploid populations were 30m (six populations), 29m + 1sm (three populations), 27m + 3sm (two populations), and 25m + 5sm and 22m + 8sm in the remaining two populations.

Tetraploid populations were present in the following manner: 40m (five populations), 39m + 1sm (three populations), 38m + 2sm, 37m + 3sm, 35m + 5sm, 32m + 8sm, 34m + 6sm, 32m + 8sm in five populations. Disploid populations had the following karyotype formulas: 44m (two populations) and 30m + 14sm, 35m + 9sm for the remaining two populations (Table 2).

Chromosomes were small and medium-small in size (between 1.0 and 3.85 µm), according to Stebbins (1938). The mean chromosome length (LMC) ranged between 1.31 µm and 2.62 µm. The centromere index varied from 12.94 to 21.76.

In general the karyotypes were moderately symmetrical and fall into categories 1A and 1B of Stebbins (1971).

The UPGMA dendrogram constructed with karyotype similitudes (Fig. 3) shows three main groups divided into subgroups. The first group is composed of three subgroups with group I-1 being composed of populations 4098, 4177, and 4016. Group I-2 was formed by populations 4215, 4140, 4170, 4124, and 4053. Group I-3 was composed of populations 4227, 3982, 4159, 4219, 4030, 4162, and 3976; and was characterized by intermediate CI value (A_1 = 0.10 to 0.14). Group two contained only two populations, 4235 and 3970; with low CI (A1 = 0.15 to 0.19). The third group was composed of three subgroups with the following populations: subgroup III-1 by 4252, 4029, and 4028, with intermediate CI value (A1 = 0.12 to 0.16); subgroup III-2 by 4203, 4166, 4210, 4234, 4202, 4187, and 4158 also with intermediate CI value (A1 = 0.03 to 0.16); and subgroup III-3 by 3993, 4146, and 3990. It is important to note that this separation into groups and subgroups is intimately related to the morphological characteristics of the inflorescence and ploidy levels. The first group contains disploid and tetraploid populations, the second group has one disploid and one tetraploid population, while the third group is completely composed of triploid populations that have an open panicle inflorescence.

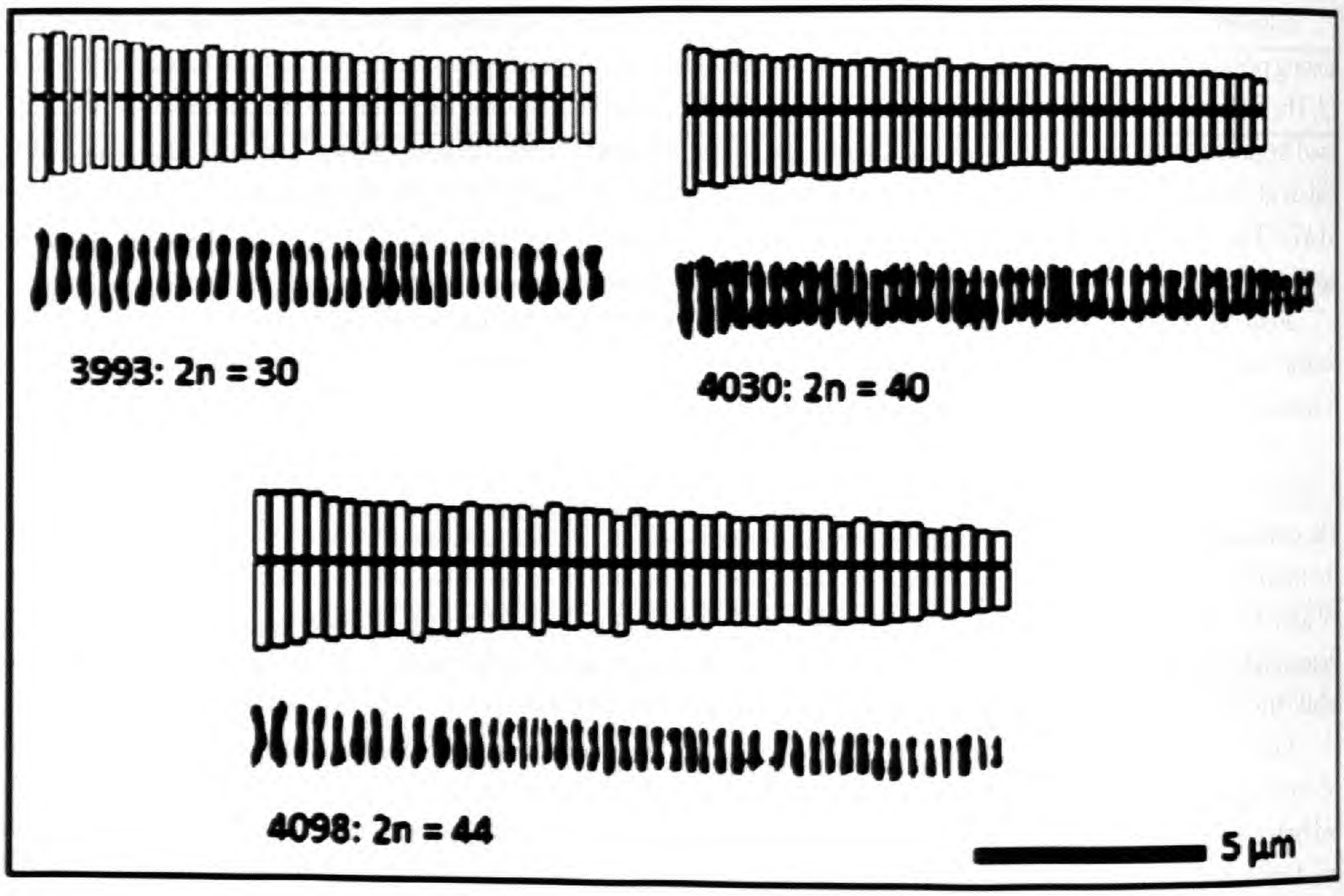


Fig. 2. Ideograms representing the three ploidy levels of *Muhlenbergia rigida* populations. Bar scale = 5 µm.

Measurements from triploid and tetraploid plants from the same locality were statistically compared resulting in significant differences ($P < 0.05$).

DISCUSSION

The results obtained from our study of *Muhlenbergia rigida* morphotypes partially confirms the previously reported chromosome numbers for this species by several authors.

Of the 30 populations examined, 13 were found to be triploid, this being the first report for triploidy in the species. Apart from the triploid cytotypes this study also found tetraploid and disploid plants, confirming the results of previous studies. The triploid and tetraploid cytotypes are present in high frequency (86%) while disploidy ($2n = 44$) had low frequency, being found in only four populations (Table 2).

This study presents ploidy levels found in *M. rigida* populations in north central Mexico. It also shows, for the first time, the karyotype and ideograms of the two *Muhlenbergia rigida* morphotypes (dense and loose panicle) as well as the three cytotypes within the species.

Polyploidy has played an important role in the evolution of many eukaryotes (Soltis et al. 1999), and the majority of angiosperms (approximately 70%) have shown polyploidy during their evolutionary process (Masterson 1994). It is highly probable that the polyploidy of *Muhlenbergia rigida* is of autopolyploidy in origin, since the cytotypes have very similarly sized chromosomes. General morphology of the studied plants was very similar (Table 2).

The results of this study reveal a detailed description of the chromosomal traits of two *Muhlenbergia rigida* morphotypes, allowing the classification of the karyotype of *M. rigida* as symmetrical. The chromosomes are small in size with an average length that does not surpass 2.87 mm, according to the classification of Stebbins (1971).

Taking into account the relative abundance of polyploids when compared to their disploid ancestors, Stebbins (1971) recognizes five maturity stages of polyploidy complexes: initial, young, mature, declining, and

TABLE 2. Populations of *Muhlenbergia rigida*: voucher number and morphotype (d = dense panicle, o = open panicle), chromosome number (*2n*), karyotype formula (KF), total chromosome length (TCL), long arm length (LCL), short arm length (SCL), mean chromosome length (LMC), centromere length (CI), intra-chromosome asymmetry index (A_1), inter-chromosome asymmetry index (A_2), Paszko asymmetry values (CV_{CI} x CV_{CL}), Paszko asymmetry index (AI), Stebbins asymmetry category(ST), SE standard error.

Populations	2n	KF	TCL±SE (µm)	LCL (µm)	SCL (µm)	LMC±SE (µm)	CI±SE	A1	A2	CVCI	CVCL	AI	ST
3970(d)	40	40m	61.29±0.97	0.84	0.69	1.53±0.02	19.63±0.07	0.98	0.15	7.77	15.35	1.19	1A
3976(d)	40	40 m	46.68±2.94	0.85	0.71	1.6±0.09	14.52±0.04	0.98	0.10	7.67	10.33	0.79	1A
3982(d)	40	40 m	45.94±0.71	0.83	0.70	1.53±0.02	15.06±0.07	0.98	0.10	6.42	10.02	0.64	1A
3990(o)	30	29m+1sm	72.95±4.88	1.37	1.03	2.40±0.17	13.01±0.07	0.97	0.19	10.69	18.82	2.02	1B
3993(o)	30	29m+1sm	72.01±5.56	1.27	0.98	2.40±0.19	13.95±0.06	0.97	0.21	10.41	20.62	2.12	1B
4016(d)	44	35m+5sm	59.52±7.94	1.14	0.85	1.98±0.12	14.86±0.05	0.98	0.13	9.69	12.68	1.23	1B
4028(o)	30	25m+5sm	39.50±1.83	0.74	0.58	1.32±0.06	14.48±0.04	0.97	0.17	10.15	16.80	1.71	1B
4029(o)	30	27m+3sm	44.64±1.15	0.83	0.65	1.49±0.04	14.62±0.06	0.97	0.17	11.03	17.42	1.92	1B
4030(d)	40	32m+8sm	55.59±2.60	1.05	0.81	1.85±0.08	14.44±0.07	0.98	0.14	10.03	13.81	1.39	1B
4053(d)	40	38m+2sm	70.56±3.09	1.38	0.98	2.35±0.10	13.86±0.04	0.98	0.14	10.24	13.8	1.41	1B
4098(d)	44	30m+14sm	59.58±1.65	1.12	0.87	1.99±0.05	14.15±0.06	0.98	0.12	9.32	11.96	1.12	1B
4124(d)	40	39m+1sm	63.32±4.26	1.06	0.91	2.11±0.14	14.18±0.09	0.98	0.16	11.15	16.36	1.84	1A
4140(d)	40	37m+3sm	55.79±4.71	1.06	0.80	1.86±0.16	13.85±0.06	0.98	0.14	10.81	13.84	1.50	1A
4146(o)	30	22m+8sm	64.55±4.37	1.22	0.90	2.12±0.14	12.94±0.07	0.98	0.15	12.42	15.22	1.89	1B
4158(o)	30	27m+3sm	47.26±2.11	0.89	0.69	1.58±0.07	13.43±0.06	0.97	0.19	9.89	18.53	1.83	1B
4159(d)	40	39m+1sm	53.07±6.29	0.99	0.78	1.77±0.21	14.56±0.04	0.98	0.11	9.51	11.14	1.06	1B
4162(d)	40	34m+6sm	49.66±0.91	0.92	0.74	1.66±0.03	14.58±0.04	0.98	0.11	8.20	11.21	0.91	1A
4166(o)	30	30m	52.74±2.15	1.06	0.85	1.76±0.08	13.37±0.05	0.97	0.16	9.09	16.46	1.49	1B
4170(d)	40	35m+5sm	56.50±3.76	1.06	0.82	1.88±0.12	14.20±0.04	0.98	0.11	10.94	10.69	1.16	1A
4177(d)	44	44m	56.36±2.23	0.95	0.80	1.75±0.07	14.99±0.05	0.98	0.12	7.96	11.79	0.94	1A
4187(o)	30	30m	48.48±2.33	0.98	0.72	1.62±0.08	13.55±0.05	0.97	0.16	8.78	16.11	1.42	1A
4202(o)	30	30m	48.76±3.04	0.90	0.73	1.62±0.10	13.51±0.05	0.97	0.15	8.33	14.74	1.22	1A
4203(o)	30	30m	55.51±2.01	1.03	0.82	1.85±0.07	13.29±0.05	0.97	0.15	8.75	14.95	1.31	1A
4210(o)	30	30m	52.74±1.98	0.97	0.78	1.76±0.07	13.41±0.05	0.97	0.17	1.53	3.11	0.05	1A
4215(d)	40	39m+1sm	78.46±5.11	1.45	1.16	2.62±0.17	14.57±0.07	0.98	0.13	10.84	12.59	1.36	1[a]
4219(d)	40	40m	56.70±2.74	1.05	0.84	1.89±0.09	14.52±0.06	0.98	0.13	10.65	12.76	1.36	1B
4227(d)	40	40m	61.74±2.18	1.14	0.92	2.06±0.07	14.98±0.09	0.98	0.14	7.34	13.81	1.01	1B
4234(o)	30	29m+1sm	39.23±2.52	0.72	0.59	1.31±0.08	13.47±0.04	0.97	0.16	8.95	15.62	1.40	1B
4235(d)	44	44m	64.99±4.91	1.18	0.98	2.17±0.16	21.76±0.02	0.98	0.12	8.49	11.95	1.01	1B
4252(o)	30	30m	60.15±1.93	1.11	0.90	2.01±0.06	14.65±0.02	0.97	0.16	8.62	16.09	1.38	1B

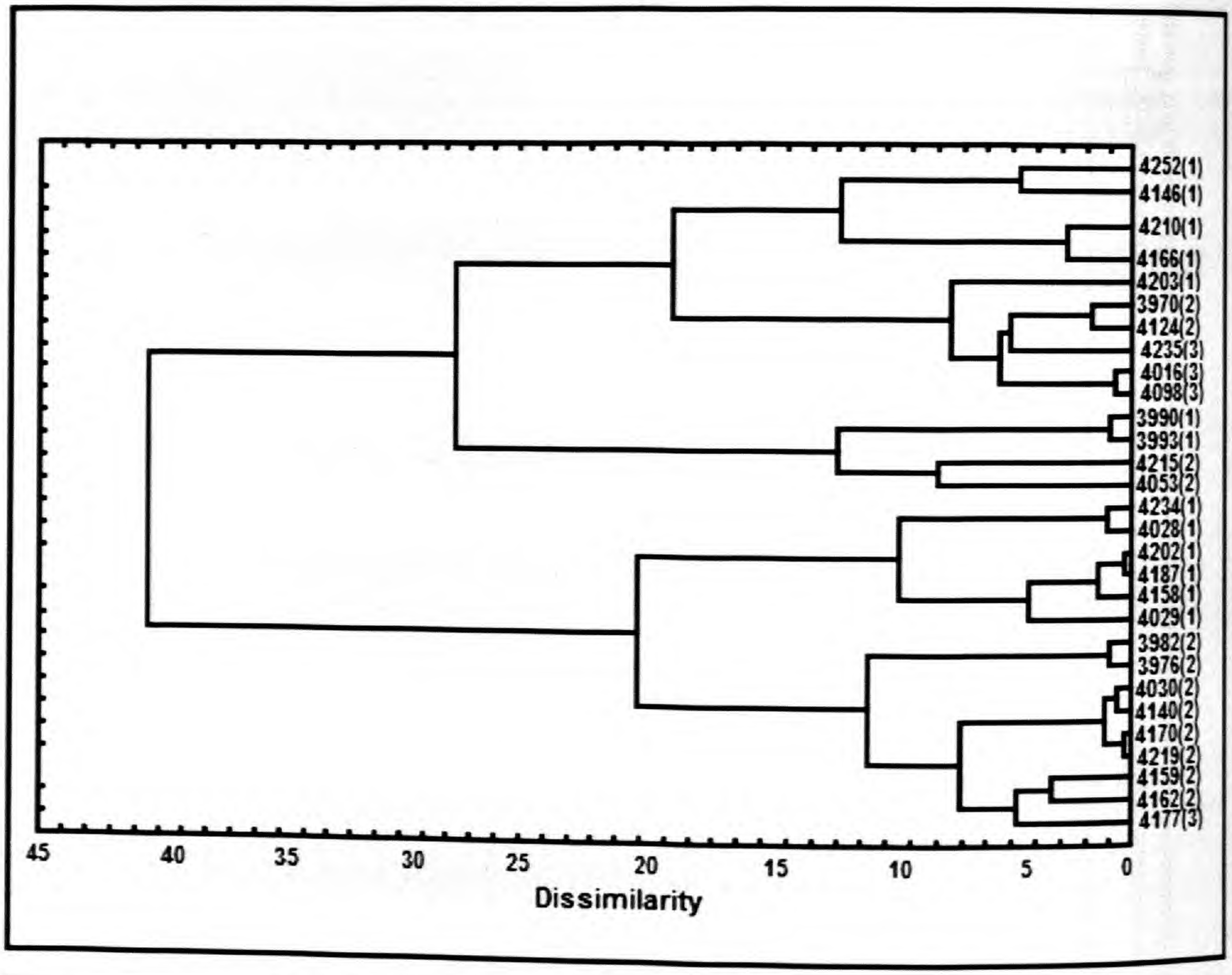


Fig. 3. Dendrogram showing the phenetic relationships among the *Muhlenbergia rigida* populations constructed using a karyotype similitude matrix with (UPGMA). (1 = triploid, 2 = tetraploid, 3 = disploid).

relictual. According to him, the evidence of distribution patterns indicates that the majority of polyploidy complexes that are currently mature originated in the Pliocene or Pleistocene. Our finding of 100% polyploidy frequency in the *Muhlenbergia rigida* populations indicates a high evolutionary maturity.

Chromosomes of studied populations can be classified from medium-small to medium-large based on Stebbins' terminology (1971). All populations have predominantly metacentric chromosomes and, to a lesser degree, submetacentric chromosomes. The A1 index fluctuated 0.1; for example, 50% of the populations had a 0.97 value while the other 50% had 0.98, which supports the predominance of metacentric chromosomes.

The *Muhlenbergia rigida* karyotype constitutes the first karyotypic description of the genus. Karyotype asymmetry was reflected in the various index values (A1, A2, AI, and Stebbins categorization). According to Stebbins' classification (1971), the karyotype asymmetry is type A1 and B1. This degree of asymmetry between populations is high, reflecting low specialization (Stebbins 1971).

The inter-chromosome asymmetry index A2 values varied from 0.10 to 0.21, indicating a similar chromosome length in most of the populations. The highest variation was observed in population 3993, where A2 was 0.21, while the lowest was observed in populations 3976 and 3982, where A2 was 0.10.

The Paszko's asymmetry (2006) calculated values (Table 2) show a low asymmetry, as the values range from 0.05 to 2.12. The most symmetrical karyotype was present in population 4210 which had a 0.05 AI value, while the most asymmetrical karyotypes were present in population 3990 (with an AI of 2.02) and population 3993 (with an AI of 2.12).

The agglomerative clustering analysis (UPGMA) revealed that the parameters which had greater influ-

ence in group and subgroup formation were the centromere index (CI) and inter-chromosome asymmetry (A2). The CI values had an interval of 12.94 to 21.76 while the inter-chromosome asymmetry index values (A2) range from 0.10 to 0.21, marking clear difference between morphotypes. Populations with the open panicle morphotype had the highest A2 values (0.15 to 0.21) while the closed panicle morphotype populations had lower A2 values (0.10 to 0.16).

The amount of metacentric chromosomes in the cytotypes studied, suggest that the karyotype of this species shows a tendency to be symmetrical, indicating a trend to become stable.

The ploidy levels of *Muhlenbergia rigida* are related to morphotypes. Plants that had compact inflorescence were tetraploid and disploid ($2n = 40$ and 44) while those with loose inflorescence were triploid ($2n = 30$). Therefore, cytological data provides a good complement to taxonomic studies. Knowledge on simple cytogenetic characteristics of a species such as chromosome number, behavior of the chromosomes during meiosis, the mode of reproduction of individuals and their fertility can contribute to a better understanding of the patterns of morphological variation and help to define taxonomic limits. The results obtained in this study confirm the differences between two morphotypes of *M. rigida*, which maintain their morphological and cytological features even when growing at the same location, and may represent two taxonomic entities. However, further evidence may be required to support their recognition at the species level.

The lack of cytogenetic information on species of *Muhlenbergia* makes the comparative study of karyotypes and their quantitative characteristics difficult, limiting deeper discussion on the possible participation of chromosome changes in the evolution of the genus, in its speciation processes, and the establishment of some type of genome specialization in relation to the habitat. It is expected that a thorough cytogenetic study (with banding, FISH, or GISH) could provide more elements to determine the evolutionary history of *M. rigida* morphotypes.

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A SURVEY OF SEED COAT MORPHOLOGY IN *OXYTROPIS*, SECTS. *ARCTOBIA*, *BAICALIA*, *GLAEOCEPHALA*, *MESOGAEA*, AND *OROBIA* (FABACEAE) FROM ALASKA

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ABSTRACT

Seed coat micromorphology for 22 of 67 species of the genus *Oxytropis* from the Arctic in sections *Arctobia* (nine species), *Baicalia* (two species), *Glaeocephala* (three species), *Mesogaea* (one species), and *Orobia* (seven species) were studied using Scanning Electron Microscopy (SEM). Three main types of seed coat micromorphology (i.e., rugulate, lophate, and foveolate) and four distinct seed shapes (i.e., reniform, mitiform, globose, and ovoid) were found. Seed coat variation was examined using multinomial regression analysis of taxonomic classification, seed dimensions and geographical distribution. The relative frequency of the seed coat types and seed shape compared to sectional classification showed section *Mesogaea* to be differentiated from sections *Arctobia*, *Baicalia*, *Glaeocephala*, and *Orobia*. *Oxytropis deflexa* of section *Mesogaea* is unique among the taxa studied in having small, globose seeds when compared with the other Alaskan taxa with larger, reniform seeds. Overall, seed micromorphology among the Alaskan members of *Oxytropis* is highly variable at the species level, with some species (i.e., *O. viscida* and *O. jordalii*) demonstrating all three seed coat types.

RESUMEN

Se estudió la micromorfología de la testa de 22 de las 67 especies del género *Oxytropis* del Ártico de las secciones *Arctobia* (nueve especies), *Baicalia* (dos especies), *Glaeocephala* (tres especies), *Mesogaea* (una especie), y *Orobia* (siete especies) fueron estudiadas por Microscopía electrónica de Barrido (SEM). Hay tres tipos principales de micromorfología de la testa (i.e., rugulada, lofada y foveolada) y se encontraron cuatro formas distintas de semillas (ej., reniformes, mitiformes, globosas y ovoides). La variación de la testa se examinó mediante un análisis de regresión multinomial de la clasificación taxonómica, las dimensiones de semillas y la distribución geográfica. La frecuencia relativa de los tipos de semillas de la capa y forma de la semilla en comparación con la clasificación seccional mostró que la sección *Mesogaea* debe diferenciarse de las secciones *Arctobia*, *Baicalia*, *Glaeocephala* y *Orobia*. *Oxytropis deflexa* de la sección *Mesogaea* es único taxon estudiado que tiene semillas pequeñas, globosas, en comparación con los otros grupos taxonómicos de Alaska con semillas grandes, reniformes. En general, la micromorfología de la semilla entre los miembros de Alaska de *Oxytropis* es muy variable a nivel de especie, con algunas especies (por ejemplo, *O. viscida* y *O. jordalii*) que demuestran los tres tipos de cubierta en las semillas.

INTRODUCTION

The genus *Oxytropis* DC. (Fabaceae, subfamily Papilionoideae, tribe Galegeae Dumort.) is taxonomically complex, comprising over 300 species worldwide (Yakovlev et al. 1996; Yurtsev 1999; Zhu & Ohashi 2000; Welsh 2001; Lewis et al. 2005). The genus is widely distributed throughout the Northern Hemisphere, with its greatest diversity found in the Tibetan plateau and circumpolar Arctic (Yurtsev 1999; Ranjbar et al. 2009). A total of 67 species are found in the Arctic, 22 of which occur in Alaska (Yurtsev 1999; Elven & Murray 2011). *Oxytropis* is thought to have derived from *Astragalus* L. approximately 12–16 Ma and consequently shares many morphological characteristics (Wojciechowski et al. 2005). A beaked keel, asymmetrical leaflets, and an acaulescent habit distinguish *Oxytropis* from *Astragalus* morphologically (Barneby 1952). Many of the taxonomic relationships within *Oxytropis* remain problematic, likely due to relatively recent diversification (reviewed in Welsh 2001).

Several times in the Quaternary during glacial maxima an ice-free, continuous land bridge extended from the Russian Far East to Alaska and Canada and played a significant role in the history of many northern taxa (Hultén 1937, 1958; Elias et al. 1996; Ickert-Bond et al. 2009). In fact, a large ice-free refugium existed from the northwestern-most Arctic in Canada to the Lena River in arctic Russia, the area defined and named Beringia by Hultén (1937). *Oxytropis* present in Beringia, range in distribution from amphi-Beringian taxa to groups endemic to eastern (Alaskan) or western (Russian) Beringia to circumpolar elements, some with extensions southward into the Rocky Mountains (Yurtsev 1997, 1999; Talbot et al. 1999; Ickert-Bond et al. 2009). The suspected recent diversification of the genus coupled with specialized niches (i.e., *O. kobukensis* S.L. Welsh, *O. kokrinensis* A.E. Pors., and *O. tananensis* Jurtz.) has resulted in high levels of intraspecific morphological variation and phenotypic plasticity. In addition, the lack of definitive taxonomic characters in some complexes, have led to difficulties and differences in species delimitation, resulting in competing taxonomies and a plethora of synonyms (reviewed in Welsh 2001).

Alexander Bunge's worldwide treatment of *Oxytropis* (1874) established four subgenera based on the presence and variation of a septum in the legume fruit and the length of the calyx teeth: I. *Oxytropis* (pod exerted above the calyx, with pod always ventrally and sometimes also dorsally septate), II. *Phacoxytropis* (pod exerted above torn calyx, without septum), III. *Physoxytropis* (small, somewhat inflated legume enclosed by intact calyx), and IV. *Ptiloxytropis* (small pods enclosed by calyx with long villous calyx teeth). Bunge (1874) furthermore distinguished 17 sections within *Oxytropis* based on leaflet arrangement, raceme size and shape, legume shape and anatomy, presence of glandular hairs, and presence of spines on the petiole. Many of Bunge's infrageneric categories are still used in taxonomic works today (Barneby 1952; Yurtsev 1997, 1999; Zhu & Ohashi 2000; Polozhij & Malyschev 2006; Malyshev 2008a, 2008b; Ranjbar et al. 2009).

Revisionary work on members of *Oxytropis* was completed by Vasil'chenko (1948), who added two subgenera exclusively of Old World taxa. In 1952 Barneby revised *Oxytropis* for North America, clarifying much of the nomenclatural issues that had arisen. Yurtsev (1997, 1999) treated the genus from a Panarctic perspective and noted the importance of substrate affinity to the distribution of certain taxa. Most recently, Welsh (2001) revised *Oxytropis* in North America, largely agreeing with the species concepts proposed by Barneby. These authors placed importance on characters such as stipule shape, pubescence type, legume shape, and substrate affinity to delineate taxa. Although the Panarctic Flora Checklist provides a unified view for all areas of the Arctic (http://nhm2.uio.no/paf), the high phenotypic plasticity observed in some taxa along with differences in species concepts between Russian and American taxonomists result in no widely accepted taxonomy for the group.

The varied climates, lithologies, and landforms (many created and modified by cold climate geomorphic processes) in Alaska generate a number of different habitats and ecological niches. Steep gradients of abiotic factors such as disturbance, elevation, and moisture result in sharply contrasting adjacent habitats. Thus weak geographic and ecological reproductive isolation among rapidly diversifying taxa might well have allowed infraspecific and interspecific hybridization in *Oxytropis* (Jorgensen et al. 2003; Artyukova & Kozyrenko 2012). These phenomena often caused by the influx of multiple rapid colonization events have occurred in a number of arctic genera including, *Artemisia*, *Cassiope*, and *Rubus* (Eidesen et al. 2007; Ehrich et al. 2008; Tkach et al. 2008).

The few morphologic and phylogenetic studies that have been conducted in *Oxytropis* have yet to yield an accepted unified taxonomy for the genus. Jorgensen et al. (2003) using ITS and RAPD markers for populations of *O. campestris* and *O. arctica* complexes in Alaska suggested that the taxa examined represent a recent radiation and are the result of multiple origins of polyploidy. Most recently, a phylogenetic study based on ITS sequence data from 35 species revealed largely unresolved relationships of the genus (Archambault and Stromvik 2012). However, the 2012 study substantiates some infrageneric relationships within the genus, namely the identification of section *Mesogaea* as the first branching lineage of *Oxytropis*, as well as multiple recent radiation events of *Oxytropis* in the Arctic.

Within Fabaceae several studies have investigated the value of seed coat micromorphological characters

as seen with SEM for identifying economically important taxa (Lersten 1981; Pandey & Jha 1988). Forty-eight species of Turkish *Astragalus* were examined (Vural et al. 2008) investigating seed micromorphology, the study revealed two distinct seed coat types (i.e., rugulate and rugulate-reticulate, terms consistent with those used in our study) and three distinct seed shapes (i.e., peroblate, suboblate, and oblate). Seed shapes were taxonomically useful only when combined with seed coat patterns in Turkish and Iranian *Astragalus* (Vural et al. 2008; Ranjbar 2009). Seed coat patterns in *Oxytropis* have been documented as rugulate, lophate, or multi-reticulate. However, only a few species have been examined (i.e., *Oxytropis riparia* Litv., *Oxytropis campestris* Hook., *Oxytropis lambertii* Pursh), and none from Alaska (Lersten 1981; Pandey & Jha 1988; Solum & Lockerman 1991). Recently Erkul and Aytaç (2010) examined 13 Turkish species of *Oxytropis* and classified seed coats as striate-reticulate, psilate-reticulate, reticulate, and striate-rugulate.

In the current paper, we exended the SEM survey of seed coat micromorphology, shape and size into the Alaskan oyxtropes. In order to test the value of seed coat micromorphology we examined representatives of sections *Arctobia*, *Baicalia*, *Glaeocephala*, *Mesogaea*, and *Orobia*. Multinominal logistic regression analysis was employed for several independent variables (taxonomic classification, seed dimensions, and geographical distribution) to describe seed coat variability.

MATERIALS AND METHODS

Our survey of seed coat micromorphology of *Oyxtropis* included 22 Alaskan taxa of the 67 arctic species that have been described (Yurtsev 1999; Elven & Murray 2011; Table 1). Most of the remaining arctic species are from the Old World (e.g., the Russian Far East, Siberia, and Scandinavia). Within the 22 Alaskan *Oxytropis*, we included nine species from sect. *Arctobia* (of 13 classified in this section), two from sect. *Baicalia* (of eight classified in this section), three from sect. *Glaeocephala* (of 13 classified in this section), one of sect. *Mesogaea* (of three classified in this section), and seven from sect. *Orobia* (of 27 classified in this section; Table 1). For four species in sect. *Arctobia* (*O. arctobia* Bunge, *O. bryophila* (Greene) Jurtz. subsp. *lonchopoda* (Barneby) Cody, *O. czukotica* Jurtz., and *O. mertensiana* Turcz.), we included additional samples that were collected from neighboring regions on the Chukotka or Kamchatka peninsulas (Russia) and the Yukon Territory (Canada).

Our study is based primarily on mature, fully expanded seeds that were removed from herbarium specimens; several immature, flattened or partially broken seeds were also examined, when insufficient material was available (Table 1). Seeds were soaked in 90% ethanol for 24 hours and air-dried. For anatomical study, seeds were soaked in a mixture of equal parts water, glycerol, and ethyl alcohol for 30 hours and samples were then hand sectioned with a razor blade. Seed anatomy was examined from representatives of each taxonomic section. For Scanning Electron Microscopy (SEM) whole and sectioned seeds were mounted on SEM stubs with double-sided tape, sputter-coated with a palladium target (60/40) in a Ladd model, and viewed with an ISI-SR-50 SEM at 15–20 kV at the Advanced Instrumentation Laboratory (AIL), University of Alaska Fairbanks. Following Lersten (1981), seed coat micromorphology was examined in regions adjacent to the hilum at magnifications ranging from 500–2000×.

Measurements of seed length (L) and width (W) were made with an ocular micrometer on a stereoscopic microscope as well as from the SEM image file with a scale bar at 30–50×. Measurements given are the mean length (measured transversely to the hilum) and width (measured longitudinally to the hilum) in millimeters (Table 1). A minimum of three specimens per taxon were examined; for every specimen three seeds were measured. Terminology used for seed shapes and seed coats follow Lersten (1981) and Barthlott (1990).

Statistical analyses.—We compared the relative frequency of seed coat types (i.e., rugulate, lophate, foveolate) with respect to taxonomic sections, species, seed length, seed width, latitude, and longitude to evaluate taxonomic, physiological, and geographical correlations. Multinomial logistical regression was performed in R version 2.10.0 (R Development Core Team 2009) using the library (Venables & Ripley 2002) with the objective of testing potential predictive variables of seed coat type. Delimitation of taxonomic section, species, latitude, longitude, seed length, and seed length-to-width ratio (L:W) were used as independent variables (IVs) in the model, with seed coat type as the dependent variable (DV). We used an information theoretical approach

TABLE 1. Specimens examined along with voucher information and locality data. * All vouchers examined are deposited at the University of Alaska Museum of the North Herbarium (ALA) (unless otherwise noted). Herbarium acronyms follow Index Herbariorum (Thiers 2008). † denotes irregular or partially broken seeds. Surface ornamentation is categorized in five types: rugulate (R), rugulate reticulate (RR), multi-reticulate (MR), lophate (L), and lophate reticulate (LR). Latitude, longitude are recorded below (Index of Plant Chromosome Numbers, IPCN).

Species	Locality	Voucher information*	Mean Length (mm)	Mean Width (mm)	Seed Shape	Surface Ornament.	Lat. (°)	Long. (°)
Oxytropis* subgen. *Oxytropis* sect. *Arctobia								
O. arctobia	Canada: Southampton Island	*Malte 119782*	1.12	1.46	reniform	R, RR	64.10	-82.50
O. arctobia	Canada: Banks Island	*Aiken 99-015* (CAN)	1.89	2.34	reniform	R, RR	73.22	-119.53
O. arctobia	Canada: Spence Bay.	*McGrath s.n.* (CAN)	1.46	1.64	reniform to mitiform	R, RR	69.53	-93.53
O. bryophila	Seward Peninsula	*Murray, Yurtsev & Kelso 10658*	2.05	1.77	reniform (†)	R, RR	65.69	-164.39
O. bryophila	Alaska Peninsula	*Jansen & Carlson 02-127*	2.05	2.2	reniform to mitiform	R, RR	58.61	-153.77
O. bryophila	Mt. Schwatka	*Parker et al. 4949*	1.44	1.99	reniform (†)	R, RR	65.88	-147.25
O. bryophila	Chugach Mts., Knik River	*Barker 02-217*	1.85	2.22	reniform to mitiform	R, RR	61.36	-148.91
O. bryophila	Nulato Hills, Debauch Mtn.	*Parker et al. 7256*	1.5	2.09	reniform	R, RR	64.51	-159.88
O. bryophila	Twelvemile Summit	*Ickert-Bond 1526*	1.63	1.95	mitiform	R, RR	65.39	-145.97
O. bryophila subsp. *lonchopoda*	Canada: Ogilvie Mts.	*Cody & Ginns 34315*	1.77	2.03	reniform	R, RR	65.29	-140.30
O. czukotica	Russia: Kamchatka	*Kharkevich 550a*	1.2	1.63	reniform	L, LR	62.35	168.90
O. czukotica	Russia: E Siberia	*Koroleva & Petrovsky s.n.*	2.28	1.82	mitiform	R, RR, MR	69.58	164.41
O. gorodkovii Jurtz.	Seward Peninsula, Minnie Creek	*Murray, Yurtzev & Kelso 11565*	1.67	1.85	reniform	R, RR	65.33	-163.63
O. gorodkovii	Ogotoruk Cr. drainage	*Hultén s.n.*	2.17	2.17	mitiform	R, RR	68.13	-165.66
O. gorodkovii	Seward Peninsula, Lost R. Drainage	*Lenarz 46*	1.86	2.25	reniform to mitiform	RR	65.45	-167.15
O. huddelsonii A.E. Pors.	Yukon-Tanana Upland, Yukon Fork	*Parker et al. 6511*	1.99	2.61	reniform to mitiform	R, RR	65.15	-143.70
O. huddelsonii	Chugach Mts., Granite Range, E of Goat Cr.	*Batten & Barker 96-321*	1.89	1.94	reniform to mitiform	L, RR	60.99	-142.01
O. huddelsonii	Yukon-Tanana Upland, Charley River	*Roland 5713*	1.47	1.99	mitiform	R, RR	64.61	-143.68
O. huddelsonii	Alaska Range, Clearwater Mts.	*Grundt s.n*	2.21	2.36	reniform to mitiform	R, LR	63.03	-147.20
O. huddelsonii	Wrangel St. Elias N.P., Nicolai Ridge	*Ickert-Bond 1640*	1.88	2.21	mitiform	R	61.45	-142.65
O. kokrinensis	Vicinity of Akillik River	*Duffy MD07-105*	2.2	2.71	mitiform	R, RR	67.33	-159.96
O. kokrinensis	Etivluk Test Well	*Murray 6889*	1.5	1.43	renifrom	RR	68.36	-156.75
O. kokrinensis	Brooks Range, Bornite	*Lewis s.n.*	1.6	1.5	mitiform	RR	67.08	-156.91
O. mertensiana	Brooks Range, Mi 271 Dalton Hwy.	*Murray 8541*	1.93	1.77	mitiform	R, RR	68.45	-149.30
O. mertensiana	Brooks Range, Carnivore Cr.	*Batten 856*	1.18	1.25	reniform	R, RR	69.28	-145.03
O. mertensiana	Russia: Chukotka, Getlyanen River	*Razzhivin et al. s.n.*	1.95	1.92	mitiform	R, RR	65.25	172.16
O. scammaniana Hult.	Wrangel St. Elias N.P., Nicolai Ridge	Ickert-Bond 1638	1.31	1.82	reniform	R, RR	61.46	-142.64
O. scammaniana	Etivluk Test Well	*Murray 6890*	1.5	1.7	reniform (†)	R, RR	68.36	-156.75
O. scammaniana	Ptarmigan Heart	*Raup, Raup, & Drury Jr. 13739*	1.3	1.33	reniform to globose (†)	R, RR	61.81	-138.58

*Table 1. Specimens examined along with voucher information and locality data. * (continued)*

Species	Locality	Voucher information*	Mean Length (mm)	Mean Width (mm)	Seed Shape	Surface Ornament.	Lat. (°)	Long. (°)
sect. *Baicalia*								
O. splendens Douglas	Eagle Creek Campground	*Ickert-Bond 1568*	1.67	1.7	reniform	L	63.16	-143.20
O. splendens	Road to Chitina, W of Tosina River	*Galen Smith 2342*	1.78	1.69	reniform to mitiform	L, R	61.65	-144.65
O. splendens	Yukon River at mouth of Woodchopper Cr.	*Parker & Batten 6218*	2.63	2.51	mitiform	L, LR	65.36	-143.35
O. tananensis	Canada: Yukon Territory, Carmacks	*Calder & Kukkonen 27976*	1.5	1.63	ovoid †	RR	62.11	-136.26
O. tananensis	Porcupine River	*Howenstein & Borron 40*	2.24	3.01	mitiform to ovoid	L, LR	67.40	-141.08
O. tananensis	Yukon-Tanana Upland Gaffney Road	*Duffy 95-710*	1.46	1.49	mitiform to ovoid	L, LR, F	64.83	-147.64
sect. *Glaeocephala*								
O. borealis Trautv. ex C.A. Mey.	Seward Peninsula, Salmon Lake	*Murray, Yurtzev, & Kelso 10984*	0.92	1.4	reniform	R, RR, LR	64.91	-164.95
O. borealis	Killik River valley, Ivisak Creek	*Parker et al. 13030*	1.58	2.01	reniform (†)	LR, MR	68.30	-154.05
O. borealis	Central Noatak R. valley, Sisiak Creek	*Parker et al. 15056*	1.22	1.71	reniform to mitiform	RR	68.00	-161.41
O. glutinosa A.E. Pors.	Mackenzie Delta's East Channel	*Sim 6092*	1.37	2.06	mitiform	RR, L	60.677	-134.129
O. glutinosa	Alaska Range, Tonzona River	*Viereck 5368*	2.1	2.45	reniform to mitiform	R, RR	62.83	-152.33
O. viscida Nutt.	Canada: Yukon Territory, vic. Burwash Landing	*Raup, Drury, & Raup 13962*	1.74	1.76	mitiform	RR, MR, F, L, LR	61.36	-138.98
O. viscida	Akmalik Creek	*Parker 7618*	1.9	2.04	mitiform to ovoid	L, LR	68.40	-154.15
O. viscida	Canada: Yukon Territory, Kluane Lake	*Raup & Raup 12908*	1.57	1.70	reniform	RR	61.55	-138.66
sect. *Orobia*								
O. arctica R. Br.	Seward Peninsula, Mystery Creek	*Murray, Yurtzev, & Kelso 11640*	1.79	2.17	reniform to mitiform	LR, RR	65.91	-163.5
O. arctica	Arctic Coastal Plain, Sagavanirktok River	*Jorgensen & Batten JJ-9-9-9-7*	1.18	1.67	reniform	LR, RR	69.56	-148.61
O. arctica var. *barnebyana* S.L. Welsh	Baird Mts., Squirrel R., 'No Name Cr.'	*Jorgensen et al. JJ-97-11-3*	1.42	1.98	reniform to mitiform	L, RR	67.44	-161.32
O. arctica var. *barnebyana*	Baird Mts., Squirrel R., 'No Name Cr.'	*Jorgensen, et al. JJ-97-16-3*	2.07	2.72	reniform to mitiform	L, LR	67.44	-161.32
O. arctica var. *barnebyana*	Baird Mts., Squirrel R., 'No Name Cr.'	*Jorgensen, et al. JJ-97-13-2*	1.77	2.66	reniform to mitiform	L, RR	67.44	-161.32
O. arctica var. *barnebyana*	Baird Mts., North Fork Squirrel R.	*Jorgensen, et al. JJ-97-10-1*	1.81	2.46	mitiform	L	67.49	-161.01
O. campestris subsp. *gracilis* (A. Nelson) Hult.	Dall Island, Grace Mtn. vic.	*Stensvold 5563*	1.67	1.86	reniform to mitiform (†)	R, L, LR	54.91	-132.95
O. campestris subsp. *gracilis*	Northway, Tetlin NWR bunkhouse	*Moran 155*	1.42	1.92	mitiform	L, LR	62.96	-141.93
O. campestris subsp. *gracilis*	Brooks Range, Mile 180 Dalton Hwy	*Jorgensen & Batten s.n.*	1.92	2.28	reniform to mitiform	R, RR, L	67.31	-150.15
O. jordalii A.E. Pors.	Alexander Archipelago	*Calhoun & Krieckhaus 63*	1.35	1.84	mitiform	MR, F	57.73	-136.06
O. jordalii	Kenai Peninsula, Upper Nuka R. valley	*Lipkin & Carlson 03-310*	1.38	1.65	reniform to mitiform to ovoid	LR, F	59.673	-150.69

Table 1. Specimens examined along with voucher information and locality data. * (continued)

Species	Locality	Voucher information*	Mean Length (mm)	Mean Width (mm)	Seed Shape	Surface Ornament.	Lat. (°)	Long. (°)
O. jordalii	Mesa Archaeological Site	*Jorgensen & Batten s.n.*	1.18	1.55	reniform	L, R	68.41	-155.8
O. jordalii	Brooks Range, Mi 271 Dalton Hwy.	*Jorgensen & Batten JJ-99-10-11*	1.01	0.87	ovoid to globose	L	68.44	-149.35
O. jordalii	Central Nigu R. valley	*Parker 7562*	1.78	2.09	mitiform to ovoid	L	68.33	-156.4
O. kobukensis	Kobuk Valley Nat. Park, Kobuk Dunes	*Duffy MD07-123*	1.82	2.55	mitiform to ovoid	L, LR	67.03	-158.76
O. kobukensis	Kobuk Valley Nat. Park, Kobuk Dunes	*Duffy MD07-119*	1.9	2.63	mitiform to ovoid	L, RR, R	67.03	-158.77
O. kobukensis	Kobuk R. valley, Paungaq Taugruk	*Lipkin 84-47*	1.74	1.94	reniform to mitiform	L, LR	67.18	-158.5
O. koyukukensis A.E. Pors.	Brooks Range, Mile 187.2 Dalton Hwy	*Jorgensen & Batten JJ-99-11-12*	1.67	1.87	mitiform	LR, L, RR	67.45	-150.13
O. koyukukensis	Brooks Range, Mile 187. 2 Dalton Hwy	*Jorgensen & Batten JJ-99-11-7*	1.54	1.7	globose (†)	F, RR	67.45	-150.13
O. koyukukensis	Noatak River, N of Twelvemile Creek	*Peter Ray N.06-10*	1.51	1.43	mitiform	R, RR	65.40	-145.91
O. maydelliana Trautv.	Seward Peninsula, VABM Bluff	*Kildaw s.n.*	2.45	2.4	reniform to mitiform	LR, RR	64.53	-163.75
O. maydelliana	Eagle Summit	*Ickert-Bond 1549*	1.53	1.77	reniform	R, RR	65.48	-145.40
Oxytropis* subgen. *Phacoxytropis* sect. *Mesogaea								
O. deflexa	Wrangel St. Elias N.P., Jack Creek	*Ickert-Bond 1595*	1.44	1.45	globose	L, LR	62.46	-143.10
O. deflexa	Central Noatak R. valley, Sisiak Creek	*Parker et al. 15052*	1.38	1.35	globose	R, L	68.00	-161.41
O. deflexa	Dalton Highway, station 5	*Ickert-Bond 1466*	1.08	1.25	globose	L, LR	67.05	-150.32

TABLE 2. Summary statistics of the multinomial logistic regression with AIC model selection of seed coat micromorphology. Delimitation of taxonomic section (referred to in table as "section"), species, latitude, longitude, length and length to width ratio. The data partition examines three primary seed coat types (i.e. rugulate, lophate, foveolate).

Independent Variables Selected	AIC Score
Section+Species+Latitude+Longitude+Length+L:WW	241.1210
Section+Latitude+Longitude+Length+L:W	231.4239
Section+Latitude+Length+L:W	228.8970
Section+Length+L:W	**228.4271**
Section+Length	232.7890
Section	234.1854

to select the most parsimonious model of all candidates by minimizing Akaike's information criterion (AIC) to determine which independent variables explain variation of seed coat type (Table 2, Akaike 1974). AIC was implemented as a relative measure for goodness of fit, which penalizes the number of parameters in the model to prevent overfitting (Akaike 1974).

RESULTS

Seed coat types and shapes.—The morphological characteristics of the seeds are summarized in Table 1. All seeds examined appear smooth under the dissecting scope and show a uniform dark to light brown pigmentation (Fig. 1). Typically the seeds are reniform, but when the lobes are unequal in lengths they are classified as mitiform *sensu* Murley (1951) (Fig. 1C–D). Fewer seeds are ovoid or globose as defined by the length-to-width ratio (Table 1; Fig. 1A–B). Seeds of *Oxytropis* examined in this study range from 0.87 mm to 2.9 mm in width and from 1.0 mm to 2.1 mm in length, with an average length-to-width (L:W) ratio of 0.874:1 (Table 1).

Seed anatomy.—The cross-sections revealed the seed coat in all specimens to be well differentiated and exotestal with the outer integument providing the mechanical layer of the seed coat (Fig. 3A). A uniseriate epidermis is covered by a cuticle on upper anticlinal walls (Fig. 3A–C), and is composed of prominent macrosclereids (Figs. 1B–C), followed by a single row of osteosclereids (hypodermis) and five to eight rows of compressed, tangentially elongate parenchyma cells of the nucellus (Fig. 3C).

Micromorphology.—Three primary seed coat types (i.e., rugulate, lophate, and foveolate) were observed with many species (i.e., *Oxytropis arctica* var. *barnebyana*) exhibiting multiple cuticular patterns among different individuals (Fig. 5). The majority of seeds (63%) in these 22 *Oxytropis* species show a rugulate seed coat characterized with irregularly roughened cuticular folds (R=rugulate, Fig. 2A–D, Table 1). Within rugulate seed coats we recognized a multi-reticulate form (MR), which consist of a secondary mesh of interlacing ridges and irregularly roughened cuticular folds and were found in 50% of the rugulate seeds examined (Fig. 2C–D, Table 1). Approximately 32% of the seeds examined demonstrated the lophate seed coat type, which consists of distinct short ridges with irregular sides forming uplifted circular or rectangular patterns (L= lophate, Fig. 2G–I, Table 1). We observed additional reticulation of the lophate type on a few specimens and recognized those as lophate-reticulate (LR, Fig. 2G, Table 1). The cuticular ridges on the lophate-reticulate pattern are relatively thin when compared to the ridges in multi-reticulate seed coats. The foveolate seed coat type characterized by irregular circular folds with blunt edges and thick cell walls raised above the seed surface were only observed on 5% of seeds examined (F= folveolate, Fig. 2E–F, Table 1). The foveolate type (Fig. 2E–F, Table 1) was found in only four species (i.e., *O. tananensis, O. jordalii, O. koyukensis, and O. viscida*).

Statistical Analysis.—Stepwise model selection of the multinomial logistic regression for the three major classes of seed coat types showed the strongest association with sectional classification, length of seed (size), and L:W ratio (shape). These factors produced the most parsimonious and descriptive model with an AIC score of 228.42 (Table 2). Seed coat type was associated with taxonomic sectional classification, since the removal of this factor increased the AIC score (ΔAIC = +10.23), indicating its significance to the overall variation observed. Two of the five sections differed in seed morphology; section *Mesogaea* had a uniquely globose seed shape and

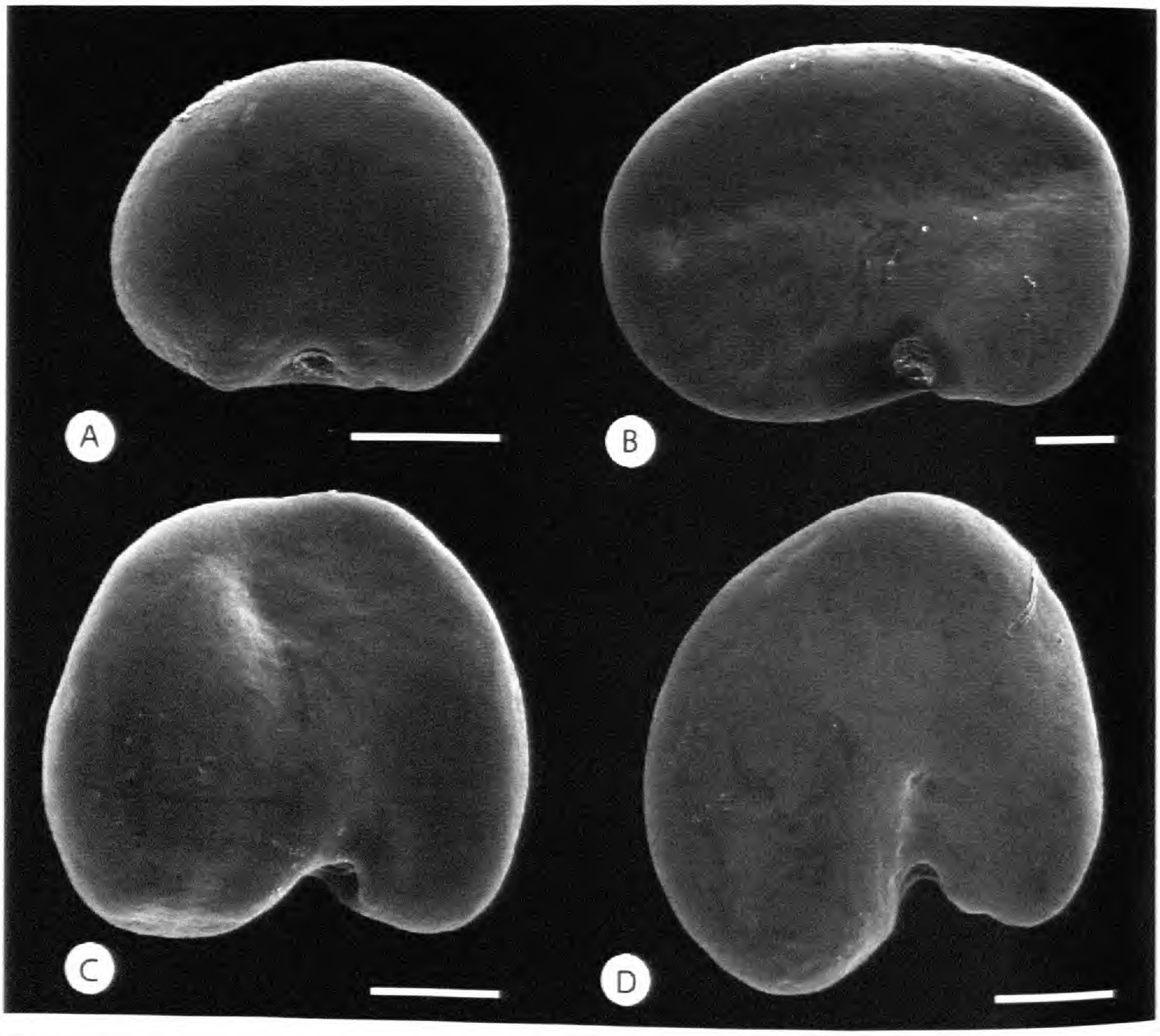


Fig. 1. Seed shapes of *Oxytropis* in Alaska using scanning electron microscopy. **A.** *Oxytropis deflexa* (*Ickert-Bond 1466*); **B.** *Oxytropis tananensis* (*Howenstein & Borron 40*); **C.** *Oxytropis borealis* (*Parker et al. 13030*); **D.** *Oxytropis campestris* subsp. *gracilis* (*Stensvold 5563*). **A.** globose seed. **B.** ovoid seed. **C.** reniform seed. **D.** mitiform seed. Scale bars A-D, 500 µm.

section *Arctobia* had less variable seed coat patterns as compared to all other sections examined (Table 2, Fig 4). Species classification explained only a minor amount of variation in seed coat type (Table 2). Similarly, length and L:W ratio explained little of the variability of seed coat type (Table 2). Latitude and longitude were the least informative of the independent variables (Tables 1, 2).

DISCUSSION

The current study has revealed several distinct seed shapes, a uniform exotestal anatomy, and three main types of micromorphology of the seed coat (i.e., rugulate, lophate, and foveolate), with most species exhibiting multiple cuticular patterns among different individuals of Alaskan oxytropes. Seeds are typically reniform to mitiform, while infrequently ovoid and globose seeds were found. Anatomically, all seeds examined have the same differentiation into an outer integument with a distinctive combination of sclereid types: an epidermal layer of macrosclerreids covering an internal layer of osteosclereids. Based on micromorphology, we recognized three seed coat types—rugulate, lophate, and foveolate—with additional variations occurring within some of these (i.e., multi-reticulate, and lophate-reticulate). All of the patterns observed in our study were previously noted in seeds of Papilionoideae by Lersten (1981). We note that seed coat micromorphology within

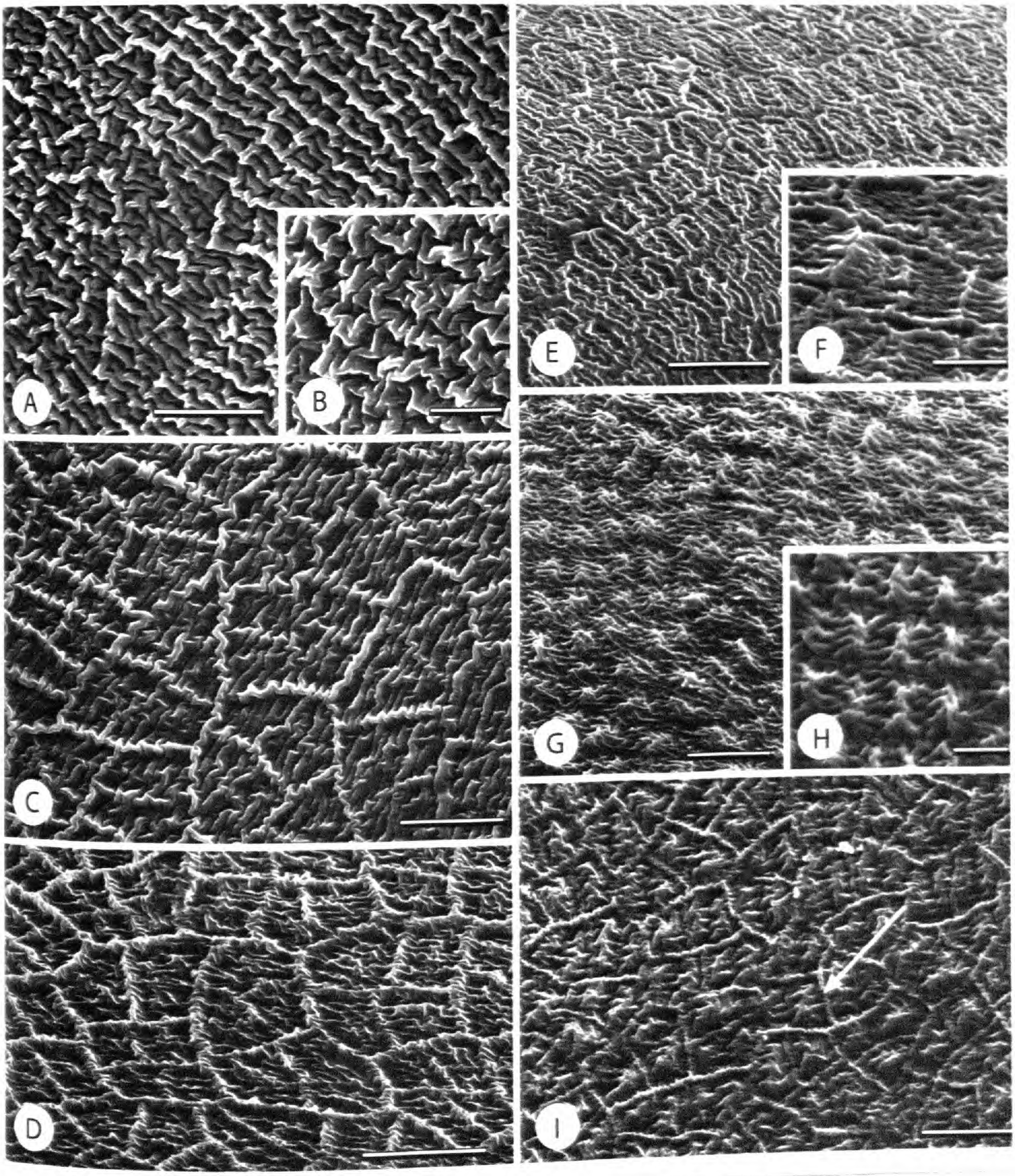


Fig. 2. Seed coat patterns of *Oxytropis* in Alaska using scanning electron microscopy. **A–C,** *Oxytopis bryophila* (*Murray, Yurtsev & Kelso 10658*); **D,** *Oxytropis czukotica* (*Koroleva & Petrovsky s.n.*); **E,** *Oxytropis jordalii* (*Lipkin & Carlson 03-310*) rugulate; **F,** *Oxytropis viscida* (*Raup, Drury, & Raup 13962*); **G,** *Oxytropis arctica* var. *barnebyana* (*Jorgensen et al. JJ-97-11-3*); **H,** *Oxytropis koyukensis* (*Jorgensen & Batten JJ-99-11-12*); **I,** *Oxytropis kobukensis* (*Duffy MD07-123*). **A,** rugulate seed coat pattern. **B,** details of cuticular folding in rugulate seed coat. **C,** rugulate-reticulate seed coat. **D,** multi-reticulate seed coat pattern demonstrating thicker secondary ridge details as compared to C. **E,** foveolate seed coat. **F,** foveolate seed coat pattern illustrating details of cuticular folding. **G,** lophate seed coat. **H,** details of the cuticular folding and regular spacing of the lophae. **I,** Lophate-reticulate seed coat showing additional ridges encircling the lophae (arrow). Scale bars A, C-E, G, I, 20 µm; B, F, H, 10 µm.

Oxytropis may be entirely of cuticular origin and not a manifestation of the underlying epidermal cells (Fig. 3A–C).

Previous studies investigating *Astragalus* and *Oxytropis* seed coat micromorphology found exotestal characters of limited use. A study that examined 48 species of Turkish *Astragalus* found only two distinct seed coat

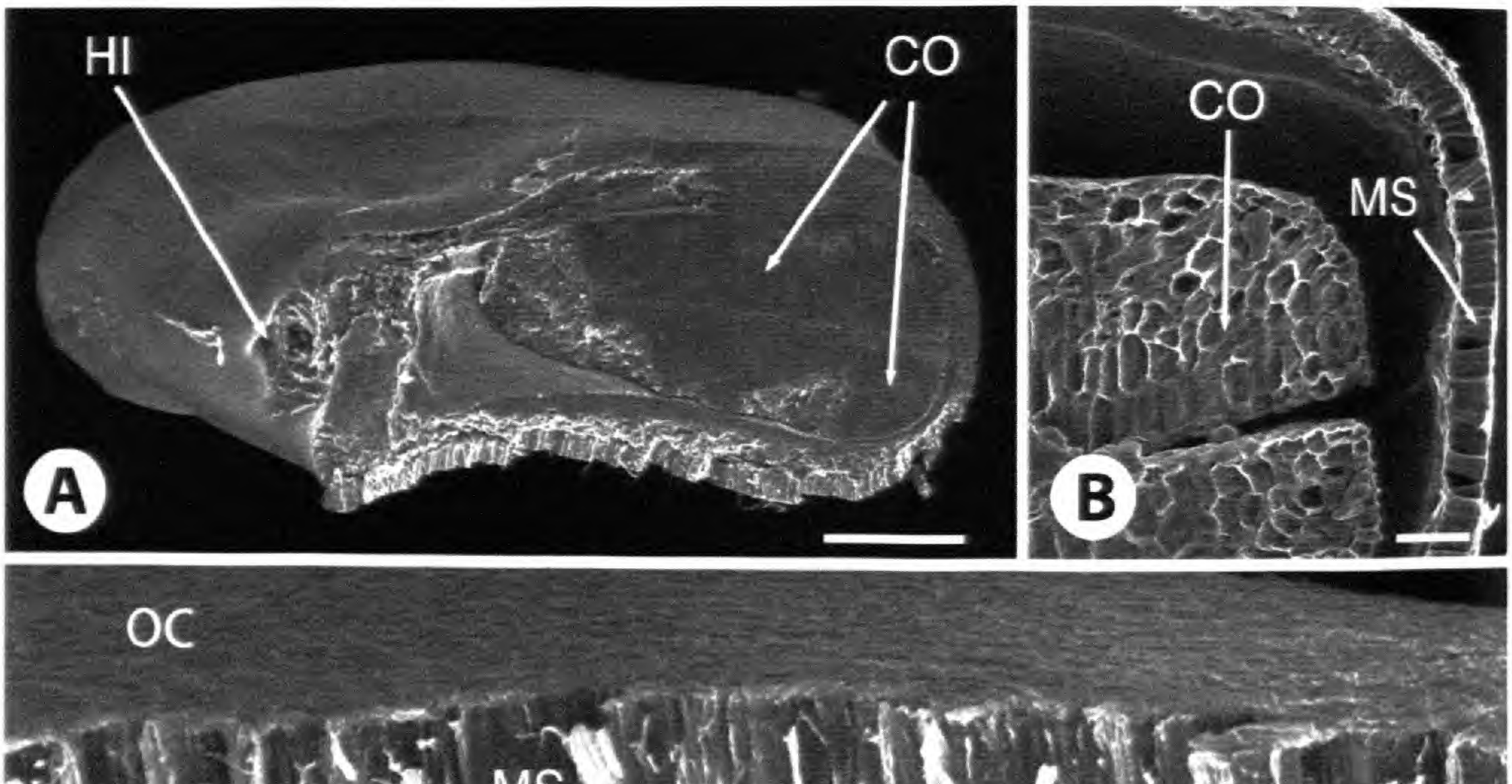


Fig. 3. Seed anatomy of selected species of *Oxytropis* in Alaska using scanning electron microscopy. **A,** *Oxytropis huddelsonii* (*Parker et al. 6511*); **B,** *Oxytropis tananensis* (*Ickert-Bond 1517*); **C,** *Oxytropis bryophila* (*Ickert-Bond 1526*). **A,** Partially sectioned seed showing position of the hilum (HI), and two prominent cotyledons (CO) filling the embryo cavity. **B,** Cross section with detailed view of edge of the seed showing macrosclereids (MS) and cotyledon (CO), outer. **C,** Cross section detailing uniform outer cuticle (OC), macrosclereids (MS) making up the outer epidermis, followed by a row of osteosclereids (OS) forming the hypodermis and tangentially elongated parenchyma cells (PA) of the nucellus. CO = cotyledon, HI = hilum MS = marosclereids, OC = outer cuticle, OS = osteosclereids, PA = parenchyma. Scale bars *A* 500 µm, *B* 100 µm, *C* 50 µm.

microphological types (rugulate and rugulate-reticulate) and three seed shapes (oblate, suboblate, and peroblate) (Vural et al. 2008). The authors concluded that seed coat patterns at both the species and infrageneric levels were of limited taxonomic utility in *Astragalus* unless supported by macromorphological characters. Similarly, 13 Turkish species of *Oxytropis* were examined and classified as striate-reticulate, psilate-reticulate, reticulate, and striate-rugulate (Erkul and Aytaç 2010). Comparison of morphology of these Turkish species with the current study is limited however as these seed coats types (striate-reticulate, psilate-reticulate, reticulate, and striate-rugulate) are not well defined in the study (Erkul and Aytaç 2010). The pioneering work of testal topography examination by Lersten in 1981 revealed tribal associations in Leguminosae subfamily Papilionoideae, specifically with Vicieae, Trifolieae, and Cicerae.

The multinomial logistic regression revealed species delimitation (independent variable) to describe the least amount of seed coat variation (dependent variable), along with latitude and longitude. These results combined with the intraspecific variability in seed coat patterns observed demonstrate that seed coat types cannot be used to discriminate species of Alaskan *Oxytropis* and are not taxonomically useful.

Historically, species delimitation in *Oxytropis* has been controversial, resulting in competing taxonomies

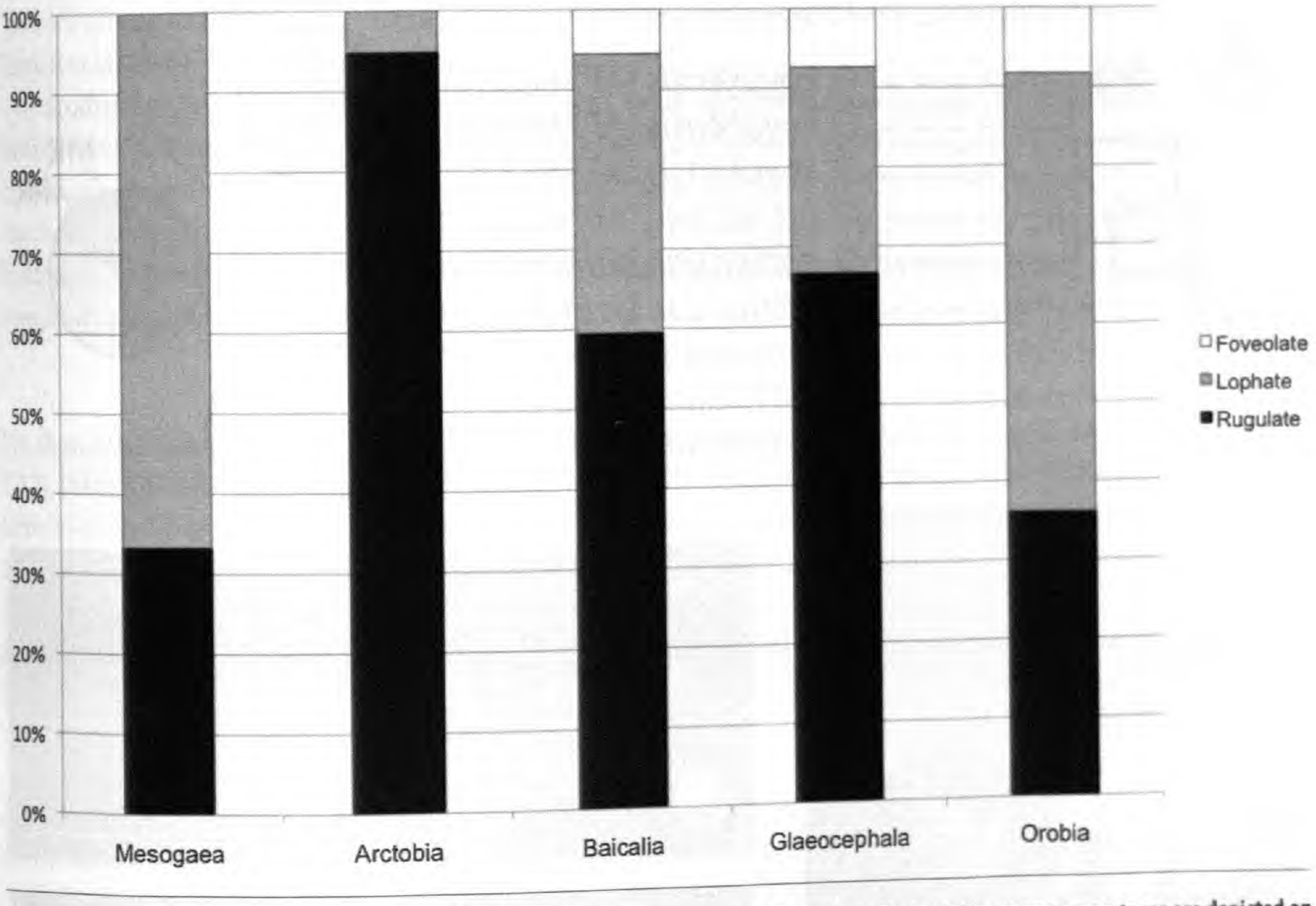


Fig. 4. Frequency of the three main seed coat types found in each of the five sections of *Oxytropis* in Alaska. Primary type percentages are depicted on a gray scale (black = rugulate; gray = lophate; and white = foveolate).

and a plethora of synonyms (reviewed in Welsh 2001) and a number of Alaskan *Oxytropis* taxa are particularly questionable (see Barneby 1952; Yurtsev 1997; Welsh 2001; Jorgensen et al. 2003; Elven & Murray 2011, and if recognized, would be taxa of conservation concern (AKNHP 2013). We find no evidence in the seed traits analyzed that support separation of *O. tananensis* from *O. varians/campestris*. *Oxytropis tananensis* has been described as a distinct taxon by Yurtsev in 1993 based on the unique presence of semiverticillate leaflets, whereas Elven and Murray (2011) sees it as part of the natural variation of *O. varians*. Welsh (2001) also synonymized *O. tananensis* with his *O. campestris* var. *varians*. Similarly, there are no seed traits that support separation of the white-flowered plants of *O. arctica* from western Alaska (*O. arctica* var. *barnebyana*, Fig. 5) from the red/blue-flowered *O. arctica* s. str. plants of the Canadian Arctic Archipelago and surroundings (Elven & Murray 2011). We stress, however, that absence of diagnostic seed characters at the species and subspecific-level does not in itself indicate a lack of taxonomic validity of these taxa.

Despite the lack of taxonomic utility at the species level, we observed some trends in frequency of seed coat types at higher infrageneric ranks. Seed coat type and seed shape were distinctive at the sectional level for sections *Arctobia* and *Mesogaea*. Seed coat patterns were most conserved in section *Arctobia* with 97% of the taxa examined being strictly rugulate. Greater variability was observed in the Alaskan members of sections *Orobia*, *Baicalia*, and *Glaeocephala*. Taxa examined from these sections all showed high intraspecific variability in seed coat types.

Despite the variability of seed shapes within sections in Alaskan *Oxytropis*, even within individual species, *Oxytropis deflexa* of subgenus *Phacoxytropis* sect. *Mesogaea* is distinct by having exclusively small globose seeds, which range from 1 to 1.5 mm in length and 1.2 to 1.6 mm in width (Table 1; Fig. 1) as compared to seeds examined from other subgenera and sections, which are generally larger and reniform (L = 0.92 to 2.45 mm, W = 1.25 to 2.72 mm, Table 1; Fig 1). Subgenus *Phacoxytropis* of Bunge (1874) was adopted by Barneby (1952) as well as Yurtsev (1997) as a distinct lineage within *Oxytropis* based on a number of vegetative and reproductive

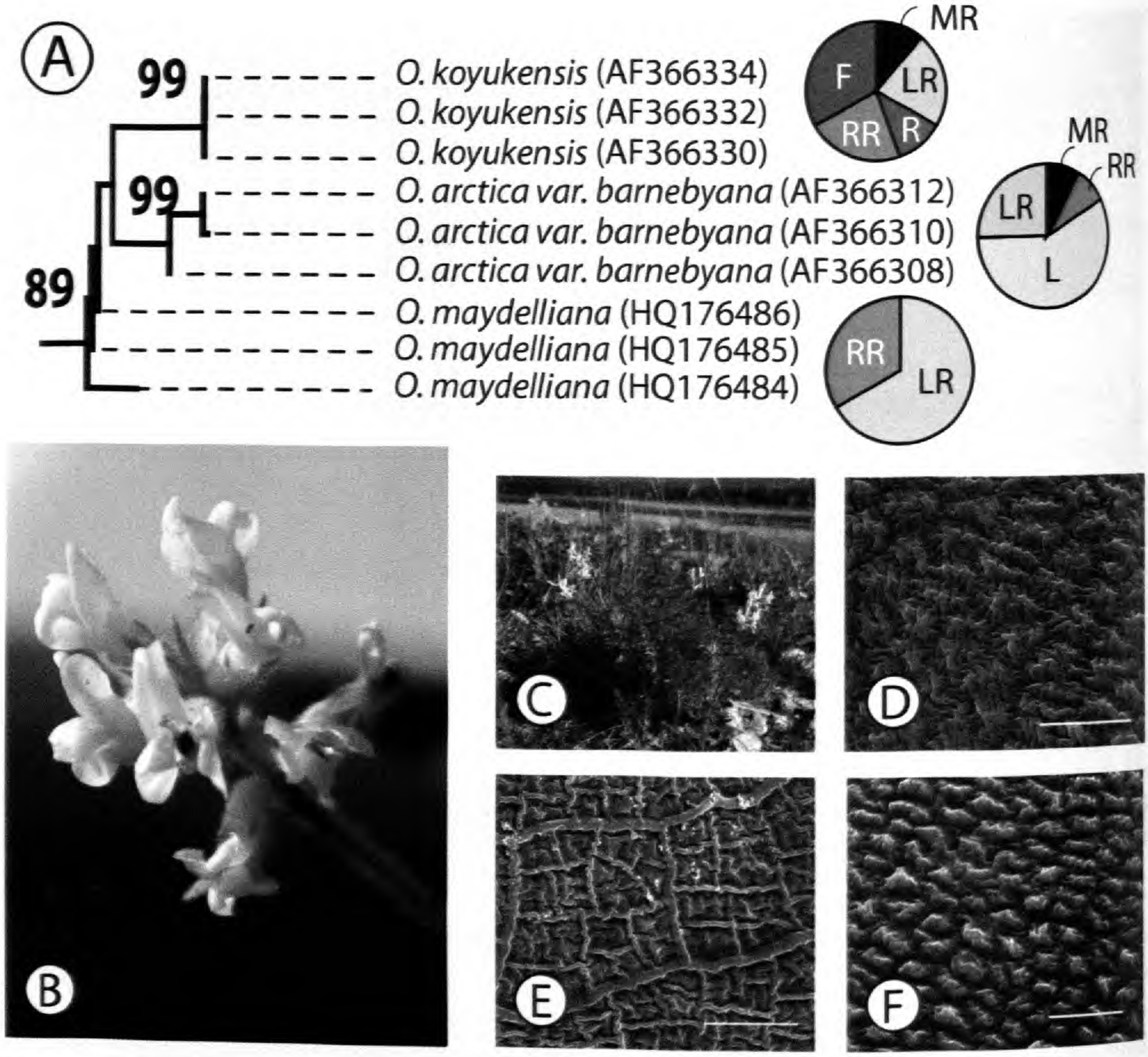


Fig. 5. Infraspecific variation of seed coat patterns in selected *Oxytropis* species from section *Orobia* in Alaska. **A.** Three species from *Oxytropis* section *Orobia* have been shown to form a well supported clade based on molecular data by Achambault and Stromvik (2012). Clade redrawn. Frequency pie graphs are shown next to the taxa at right. Node support (Bayesian posterior probability) is indicated above nodes. Seed coat types are F = folveolate, L= lophate, LR = lophate-reticulate, MR = multi-reticulate, R = reticulate, RR=Rugulate-reticulate. B.-F *Oxytropis arctica* var. *barnebyana*. **B.** Close-up of flowers with distinctive purple tinge at the keel. **C.** Habit on the Seward Peninsula, western Alaska. **D.** Reticulate seed coat pattern. **E.** Rugulate-reticulate seed coat pattern. **F.** Lophate seed coat pattern. Scale bars *D–F* 20 µm.

characters. Molecular evidence strongly support section *Mesogaea* as being an ancestral lineage of *Oxytropis* (Archambault & Stromvik 2012). In addition, mat*K* sequence data for 637 legume taxa including seven species of *Oxytropis*, *O. deflexa* was shown to be the earliest diverging branch (unpublished data, Martin F. Wojciechowski, Arizona State University, Tempe, Arizona). However, additional samples of Asiatic members in subgenus *Phacoxytropis* are needed to test whether small globose seeds represent the plesiomorphic seed shape and that reniform seeds represent the derived (apomorphic) condition in *Oxytropis*.

It is crucial to continue reporting detailed observations on morphological diversification as they reveal patterns of evolution in the genus *Oxytropis*, particularly since arctic members have been reported to be the result of recent rapid radiations and hybridization involving polyploidy (Jorgensen et al. 2003; Archambault and Stromvik 2012; Artyukova & Kozyrenko 2012). It is possible that the lack of consistent seed morphology within species is due to past introgression and more current hybridization. Similar rapid colonization events

have occurred in a number of other arctic genera including, *Artemisia*, *Cassiope*, and *Rubus* (Eidesen et al. 2007; Ehrich et al. 2008; Tkach et al. 2008).

Studies investigating the importance of ecology in the speciation process might be particularly promising in *Oxytropis*, where sympatric species are documented to inhabit different ecological niches. For example, *O. czukotica* is an acidophilous species while *O. gorodkovii* is calcicolous (Yurtsev 1999). Also evidence is mounting that populations adapt to similar environments via different genetic pathways (Steiner et al. 2009) further confounding the issue. Taxonomic resolution in a complex genus such as *Oxytropis* will only be achieved using a multi-level approach that integrates phylogenetic, morphological, and ecological investigations.

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THE FORGOTTEN FIRST CHECKLIST OF THE IOWA FLORA: JOHN HENRY RAUCH'S 1851 "REPORT" TO THE STATE MEDICAL AND CHIRURGICAL SOCIETY

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ABSTRACT

The first major account of Iowa's flora has never been cited in the literature. Compiled in 1851 by Dr. John Henry Rauch of Burlington at the behest of the Iowa State Medical and Chirurgical Society, it was published a full two decades before the supposed first effort toward a state flora by Charles Bessey. Rauch listed 516 species in 93 "natural orders," which equate to 501 species in 84 families as recognized today. This represents 23% of the species known to be native to Iowa plus 15% of the non-native. Eighty-six species not currently documented from Iowa were reported, some of which may represent early extirpations of peripheral populations. Rauch's report was a major achievement, and provides the modern reader with valuable insights into Iowa's flora and the status of botanical work there, just five years after statehood.

RESUMEN

El primer gran compendio de la flora de Iowa no ha sido citado nunca en la bibliografía. Fue compilado en 1851 por el Dr. John Henry Rauch de Burlington por mandato de la Sociedad Medica y Quirúrgica del Estado de Iowa, fue publicado dos décadas antes que el supuesto primer esfuerzo para realizar una flora del estado por Charles Bessey. Rauch listó 516 especies en 93 "órdenes naturales," que equivalen a 501 especies en 84 familias como se conocen actualmente. Esto representa el 23% de las especies conocidas como nativas de Iowa y el 15% de las non-nativas. Se citaron 86 especies no documentadas actualmente para Iowa, algunas de las cuales puede representar eliminaciones tempranas de poblaciones periféricas. El compendio de Rauch fue un gran logro, y aporta al lector moderno valiosos conocimientos de la flora de Iowa y el status de trabajo botánico allí, justo cinco años después de convertirse en estado.

INTRODUCTION

The "first effort toward a flora of Iowa" recognized by Eilers (1975) was the checklist by Bessey (1871); it indeed has been viewed as such by the state's botanists since Arthur (1876) called it "the first and only 'Contribution to the Flora of Iowa' thus far made." Prior mentions of plants from Iowa were few; the "earliest significant record" according to Eilers was Parry (1852). However, the Iowa reports in Parry's catalogue were scattered throughout a work devoted primarily to Minnesota and Wisconsin (Ellsworth 1922). Of the 727 species listed, only 204 (most collected at Davenport in 1847) were explicitly ascribed to Iowa. Some of the remainder in fact were collected in the state, as shown by Parry's notebook in the Putnam Museum (cf. Guldner 1960), and by a brief excerpt published in a local newspaper (Parry 1847), but in the catalogue bore only imprecise localities (e.g., "throughout the Northwest" or "banks of the Mississippi") or no locality at all. A reader of that time could only wonder if a "common" species such as *Mimulus ringens* L. or *Sanguinaria canadensis* L. actually occurred in Iowa or not.

The only earlier mention of Iowa plants which Eilers (1975) knew was Torrey (1843, 1845), which summarized Karl Andreas Geyer's collections from the upper Mississippi watershed (McKelvey 1955). As with Parry (1852), Geyer's work in Iowa was peripheral to a survey of more northerly regions; his specimens from the state were gathered mostly at Spirit Lake, 29 September through 3 October 1838 (Shimek 1915; Bray & Bray 1976).

Recently, I had occasion to delve into the life and career of Dr. John Henry Rauch, a physician who resided at Burlington, Iowa, during the 1850s. In my research, I came across the statement in several biographical sketches (Anonymous 1894a, 1894b, 1894c; Wilson & Fiske 1900; Kelly & Burrage 1920) that Rauch, as a member of the fledgling state medical society, had been appointed to report on "the medical and economic botany of Iowa," a report that was completed and published in 1851.

This came as a complete surprise to me. In 35 years of interest in the Iowa flora, I had seen *no* mention of such a publication. Surely, I thought, if it were of even the slightest botanical merit, it would have been known to Fitzpatrick (1899), Gilly (1947), Shimek (1948), Thorne (1954), or others. I could only assume that it was merely a few pages of quaint narrative about a handful of plants, identified largely by vernacular names of imprecise application. But when I at last located a copy (Rauch 1851a), I was astonished to find that it was an actual checklist of the Iowa flora, in many ways comparable to the first floristic list for Illinois (Mead 1846). It reported twice as many species as Parry (1852), following the nomenclature of leading contemporary botanists. In the quality and quantity of information provided (observations on habitats, phenology, distribution within the state, etc.), it was far superior to the bare-bones listings of Bessey (1871) and Arthur (1876). And it had been completely forgotten!

Rauch's (1851a) report offers a unique glimpse at Iowa's flora just 18 years after settlement began. At that time, the frontier lay a mere 50–75 miles west of the Mississippi River, and the state still contained millions of untilled acres (Plumbe 1839; Galland 1840; Newhall 1841, 1846; Parker 1855). By the time Bessey's (1871) contribution was published, the state was essentially settled and largely in cultivation (Fite 1966). As such, this forgotten first checklist provides valuable insights on the flora of Iowa prior to settlement, and enhances our understanding of how it changed following the advent of widespread agriculture and the closing of the frontier (Thompson 1980; Farrar 1981). It also casts light on a time when floristic study was largely the purview of dedicated amateurs rather than paid professionals (Stuckey 1978, 1984; Rudolph 1988), and on early interest in the therapeutic value of plants, an interest that continues today (Lewis & Elvin-Lewis 1995). The purpose here is to assure for Rauch's report the signal position it deserves in Iowa's botanical history, by carefully analyzing and interpreting the information that it contains.

BIOGRAPHY OF DR. JOHN H. RAUCH

John Henry Rauch (Fig. 1) was born on 4 September 1828 in Lebanon, Pennsylvania, the first of ten children born to Bernhard Rauch and the former Jane Brown (Beatty 1991). He assembled his first herbarium as a student at Lebanon Academy (Lee 1895). After graduating in 1846, he spent a year under the tutelage of local physician and surgeon John Washington Gloninger (1798–1874), himself a student of the eminent botanist-physician David Hosack (Kelly & Burrage 1920). Rauch then enrolled in the medical department of the University of Pennsylvania. Upon completing a thesis on the medicinal value of *Polygonatum officinale* L., he graduated an M.D. on 20 March 1849.

Iowa years.—In March 1850, Rauch came to Burlington, Iowa, to establish his medical practice. Advertisements in local newspapers (Fig. 2) place his offices on Jefferson St. (*Burlington Daily Telegraph*, 9 June 1851); on Main St. (*Burlington Daily Hawk Eye*, 2 March 1853); and on Third St. (*Daily Hawk Eye & Telegraph*, 9 December 1856). Not only did he practice, but he conducted medical research as well, examining the efficacy of topical applications of chloroform in alleviating various conditions (Rauch 1851b), the influence of ozone on health (Lee 1895), and the relationship between burial of cholera victims and spread of the disease (Beatty 1991). His advocacy for the men employed in navigation on the Mississippi resulted in his appointment to the commission charged with selecting sites for U.S. Marine Hospital Service facilities, one of which was located in Burlington (Kelly & Burrage 1920; Williams 1951).

On 19 June 1850, Rauch was one of twenty-five physicians who met at Burlington to establish the Iowa State Medical and Chirurgical Society, which in 1856 shortened its name to the Iowa Medical Society (Watson 1894; Fairchild 1927; Lawrence 2003). Rauch played an active role in this organization, serving in turn as Librarian (Ransom 1851), Recording Secretary (Anonymous 1854a), First Vice President (Beatty 1991), and President (Anonymous 1858a, 1859). He was also a founding member of the Des Moines County Medical Society, established in 1852, serving as its first Corresponding Secretary (Beatty 1991).

Rauch's interests in this period were not confined to medicine. As Lee (1895) commented, "He was a man of too enlarged views, and possessed of too much public spirit, to be content with the ordinary drudgery of medical practice, and the mere accumulation of wealth had no charms for him. The natural sciences, on the

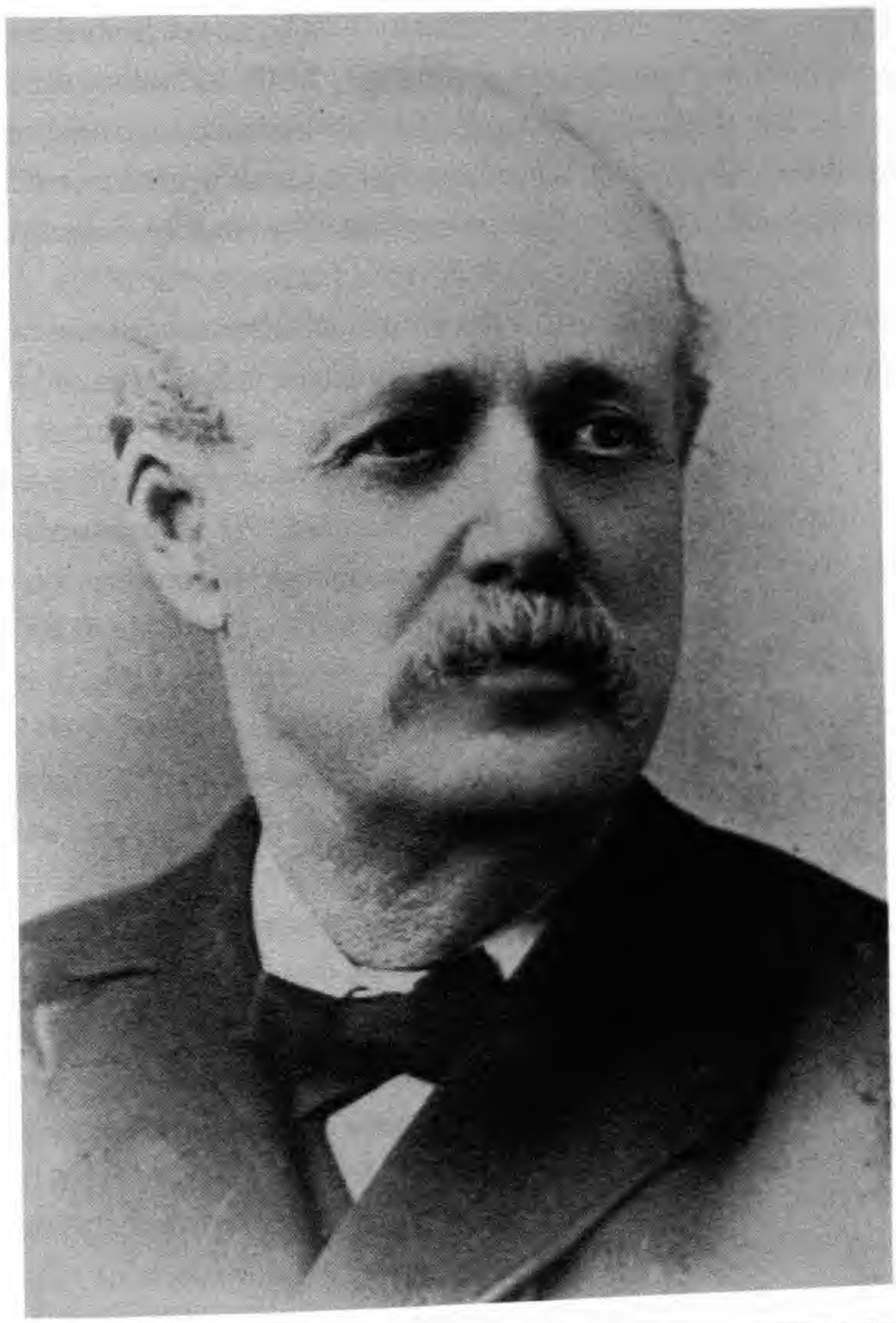
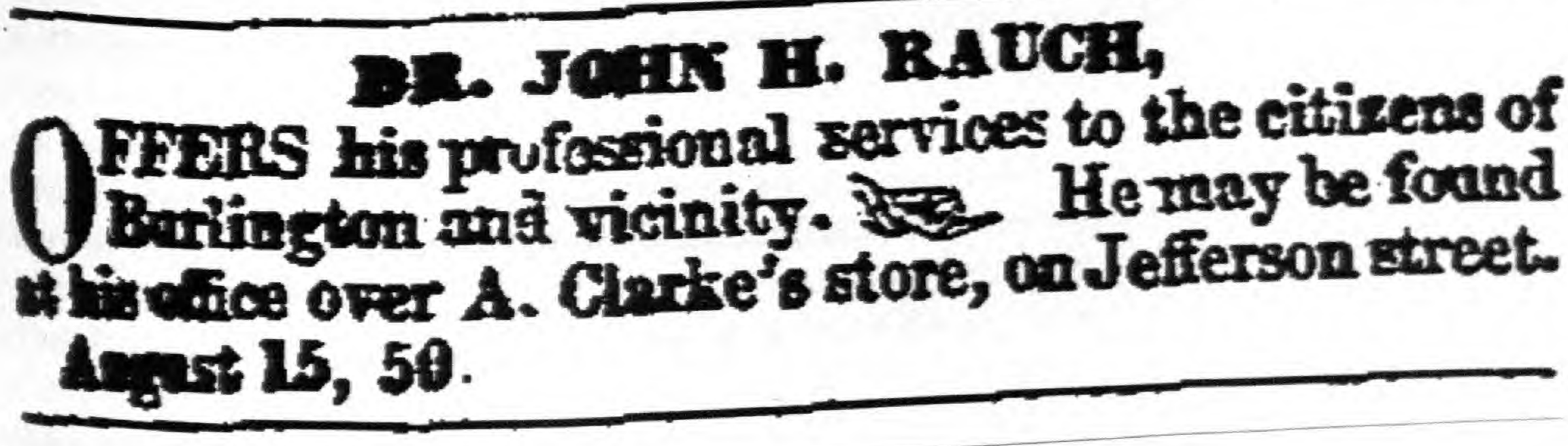


Fig. 1. John Henry Rauch, M.D. (1828–1894). Undated portrait, courtesy of the Galter Health Sciences Library Special Collections, Feinberg School of Medicine, Northwestern University, Chicago, Illinois.



DR. JOHN H. RAUCH,

OFFERS his professional services to the citizens of Burlington and vicinity. ☞ He may be found at his office over A. Clarke's store, on Jefferson street.

August 15, 50.

Fig. 2. Advertisement for Rauch's medical practice in the *Burlington* (Iowa) *Daily Telegraph* for 9 June 1851.

other hand, strongly attracted him." Rauch was among those who campaigned for state funding of a geological survey (Kelly & Burrage 1920), which came to fruition in the report of Hall and Whitney (1858). For at least one semester, he was a member of the faculty at Burlington University (cf. Johnson 1855, Abernathy 1907), serving as Lecturer on Natural Sciences (*Daily Hawk Eye & Telegraph*, 10 September 1855). While in Iowa he assembled a large zoological collection, which he took to Louis Agassiz (1807–1873) at Harvard University as houseguest

and private pupil (Anonymous 1894d, Hamilton 1894; Beatty 1991). The celebrated zoologist described several new species of teleost fishes from this collection (Agassiz 1854, 1855), including the cyprinids *Chondrostoma pullum*, *Hypobsis dorsalis*, and *Rhinichthys meleagris*; and *Ichthyobus rauchii*, a catostomid named in his honor. Numerous Rauch specimens were also cited in his monograph of North American turtles (Agassiz 1857). After Agassiz's death, Rauch was appointed to the celebrated zoologist's memorial committee, serving among such luminaries as Henry Cabot Lodge and Oliver Wendell Holmes, Jr. (Lawrence 1876).

Reflecting these broad interests, Rauch was active in at least three other local organizations besides the medical societies. The Iowa Historical and Geological Institute (see below) counted him among its members (Wilson & Fiske 1900); he served at least one term as Recording Secretary (Parker 1855) and at the group's fifteenth anniversary meeting, he was acknowledged for donating 26 examples of Canada's new one-cent coinage (Anonymous 1858b). He delivered the keynote address (Rauch 1853) at the annual meeting of the Southern Iowa Horticultural Society on 20 October 1852. Likely it was through this connection that he "received a great variety of Seeds from the Commissioner of Patents for distribution" to the public (*Daily Hawk Eye & Telegraph*, 20 November 1856). Rauch was also a Mason, a member of Des Moines Lodge, No. 1, in Burlington, and Grand Orator of the Iowa Lodge for 1854 (Parvin 1858). At the national level in these years, he was a member of the Academy of Science of St. Louis (Anonymous 1856), the Chicago Academy of Natural Sciences (Sperry 1904), the Maryland Historical Society (Anonymous 1854b), and the American Association for the Advancement of Science (Anonymous 1857a).

A local eulogist summed up well the high regard felt for Rauch during these years by his fellow Burlingtonians (Anonymous 1894a):

> He was a leader in the society of his day and no event of importance was deemed complete without him. He was always foremost, too, on all public occasions of a semi-social character, as the opening of the [Chicago, Burlington, and Quincy Railroad], etc. He was a great admirer of ladies and was highly esteemed in turn, yet died a bachelor. A street in Northern addition was named Rauch in his honor, but some supersapient city council saw fit to change the name to Garnet, thus defeating the purpose of perpetuating the memory of a one time prominent citizen.

Military service.—In response to the federal government's call for volunteers to oppose the secession of southern states, Rauch enlisted in the Army Medical Service in May 1861 (Lee 1895; Sperry 1904). He served at the First Battle of Bull Run and was afterwards made brigade surgeon. After posting to Arlington, Virginia, he became assistant medical director for the Army of the Potomac, in which capacity he participated in the Battle of Cedar Mountain, the Second Battle of Bull Run, and the Battle of Antietam. Early in 1863, he was transferred to the Army of the Gulf, serving as special medical inspector and participating in the Siege of Port Hudson and the Second Battle of Sabine Pass. Relieved from combat-zone duty in 1864, he was appointed medical director at Fort Wayne in Detroit, Michigan, and then at the army post in Madison, Indiana. At the latter posting, he was brought before a board of inquiry by a malicious subordinate on an array of charges, but all were found to be without merit (Beatty 1991). He was brevetted lieutenant colonel effective 13 March 1865 and honorably discharged on 14 July 1865 (Anonymous 1887).

Chicago years.—In 1857, Rauch became Professor of Materia Medica at Rush Medical College in Chicago, Illinois, though he maintained his residence in Burlington until autumn 1858 (Wilson & Fiske 1900; Beatty 1991). Early the next year, he resigned this position. That September, he became Professor of Materia Medica at the Chicago College of Pharmacy, the first such school west of the Alleghenies and one of the predecessors of today's University of Illinois at Chicago (Hamilton 1894). Upon his return from military service, Rauch became interested in the relationship between urban land use and public health (Wilson & Fiske 1900). He criticized contemporary burial practices as all-too-conducive to the contamination of groundwater and spread of disease (Rauch 1866, 1885), and advocated the planting of trees and the development of public parklands as a means of promoting salubrity (Rauch 1853, 1869). These efforts intersected in the closure of the decrepit City Cemetery and its rehabilitation as an addition to Lincoln Park (Beatty 1991; Szczygiel & Hewitt 2000).

In 1867, Rauch was appointed to a six-year term on the city's newly created Board of Health, where he

served as sanitary superintendent in the office of sanitary inspectors. His tenure with this agency was a constant battle with powerful commercial interests polluting the Chicago River. "By simply shutting his eyes at any time during that period, he could undoubtedly have secured an independent fortune. But his sturdy 'Pennsylvania Dutch' ancestry forbade the thought of any such venal dereliction" (Lee 1895). An even greater challenge came in the aftermath of the catastrophic conflagration of October 1871, when he was responsible for the health of 112,000 homeless citizens (Hamilton 1894). When smallpox appeared in the refugee camps, he obliged everyone there to be vaccinated, thus preventing calamity (Lee 1895). In recognition of his preeminent experience as a sanitarian, he was elected president of the American Public Health Association in 1876 (Rauch 1878; Davenport 1957).

Despite his professional focus on sanitation and public health during these years, Rauch maintained a strong interest in natural history. In the winter of 1870–71, he traveled to Venezuela to study sanitary conditions for the Orinoco Mining and Exploring Co. (Beatty 1991). Here "he made a large and valuable collection of natural objects for the Chicago Academy of Natural Sciences" (Sperry 1904). Unfortunately, no Rauch specimens of any sort are to be found in the Academy's collections today; likely all were destroyed in the firestorm of October 1871 (Dawn Roberts, pers. comm.). Rauch's personal herbarium, a manuscript entitled "Synopsis of the Flora of the North West," and all of his notes from his South American sojourn were also lost in that historic conflagration (Beatty 1991).

In 1877, the Illinois legislature created the State Board of Health. Rauch, after more than a decade of service to Chicago in this field, was an obvious candidate for membership. He was elected the Board's first president, and then served as secretary the remainder of his tenure (Anonymous 1894b; Davenport 1957). For the next 15 years, he crusaded against "untrained and unscrupulous pretenders to the medical arts" (Lee 1895), "the quacks and charlatans who were preying upon the public, who could not pass an examination in the profession which they claimed to be qualified to practice; who imposed upon the credulity of the ignorant, and wrung the last dollar from the victims of hopeless disease on pretense of being able to effect their cure" (Anonymous 1891). To do this, he rigorously and uncompromisingly enforced the provisions of the Practice of Medicine Act (Percy 1908). Under this 1877 law (cf. Anonymous 1882a), the State Board of Health verified the genuineness of the medical school diploma of every person practicing medicine in Illinois; if a physician was not a medical school graduate (as was often the case in the Nineteenth Century), he was subjected to an examination to determine his qualifications to practice (Webster 1909). During the first 18 months of its existence, this law compelled almost 40% of Illinois' 3600 non-graduate physicians to cease practicing in the state (Anonymous 1894d). "What the entire American Medical Association failed to effect by resolution and declamation through a series of decades, he accomplished in as many years by the simple expedient of establishing a standard of medical acquirement in the west to which the colleges in the east were compelled to conform" (Lee 1895).

These efforts earned Rauch many enemies – powerful enemies with powerful allies in the state legislature (Webster 1909). In both 1889 and 1891, the Board's biennial appropriations were held hostage to demands by legislators for his resignation. Newspapers aligned with the Democratic Party printed calumnious editorials, calling Rauch "obnoxious … exceedingly arbitrary in some cases, while in others ... over lenient. … his acts generally have been such as to create the feeling that he was either corrupt or incompetent" and accusing him of paying bribes to prevent revelation of damning facts about his personal integrity (Anonymous 1892a). Republican newspapers rushed to his defense, pointing out that "No capable physician was his enemy, no community where he had checked disease, or prevented the incursion of epidemics, opposed him, only those whose empiricism was exposed by his efforts to protect the people" (Anonymous 1891). The embattled Rauch finally resigned, effective 30 June 1891.

In November 1893, Rauch returned to his hometown in Pennsylvania, "wearied, worried, despondent and in ill health" (Guilford 1908). Here he took up residence in the home of his youngest brother, Cyrus (Anonymous 1894e; Beatty 1891). He died there of heart failure on 24 March 1894, and was buried in Mount Lebanon Cemetery (Lee 1895).

PREPARATION OF THE "REPORT"

At its inaugural meeting in June 1850, the Iowa State Medical and Chirurgical Society passed a resolution calling for the preparation of a report on plants of medicinal and other economic value that were to be found in the state (Matthews 1850). The committee appointed to carry out this task was chaired by Dr. John W. Brookbank of Burlington (Anonymous 1850); its other members were Rauch and Dr. John F. Dillon of Farmington (Matthews 1850, Sanford 1850). Regarding this committee and its charge, Sanford (1850) commented,

> The floral riches of this beautiful and charming state seem almost inexhaustible, and no one doubts that, amidst this profusion of nature's eloquent and poetic beauties, mines of medicinal wealth exist, from which the balm to many an ill, incident to our country, may be bountifully drawn. Numerous as are the blessings which spring from the bosom of our mother earth, they may be greatly multiplied by the assiduity of the medical botanist, and we sincerely trust a larger proportion of our physicians may be found devoting their attention to this subject. Our medical plants should be known and accurately classified in order that we may resort to the great storehouse of nature—the fields and the forests—where no mercenary hand mingles with their life-giving principles, the seeds of death.

The finished report was read by Rauch at the Society's second annual meeting, held on 7 May 1851 in Fairfield. He stated that preparation of the report fell to him "in the absence of the chairman of the committee." In fact, neither Brookank nor Dillon was practicing medicine during most of the year between the committee's formation and the presentation of the report, and all evidence points to Rauch as sole author.

John Forrest Dillon (1831–1914) was at that time but 19 years old. He was one of five graduates that spring from the College of Physicians and Surgeons of the Upper Mississippi in Davenport, a forerunner of the University of Iowa School of Medicine (Watson 1894), and was en route to Farmington to commence practice (Stiles 1909). There he discovered that a medical condition (an inguinal hernia) made it very painful for him to ride horseback, a requisite for a physician in that rough and thinly settled country. By that autumn, he had given up the practice of medicine, though not his membership in the Society (Anonymous 1854a) and not before publishing on one of his cases (Dillon 1850). He returned to Davenport, took up the study of law, and was admitted to the Scott County bar two years later. His career as a jurist was long and illustrious. He founded and for many years edited the *Central Law Journal*, was elected to the state Supreme Court (Chief Justice 1868–69), and served as a professor of law at Columbia University and later Yale (Gue 1903).

Little is known about John W. Brookbank (Fairchild 1927). He was apparently the first physician to practice at Wapello in adjacent Louisa County, and represented that county at the 1844 state constitutional convention (Springer 1912). Some time later, he moved to Burlington and entered a partnership with Dr. H. Houghton; that affiliation was dissolved "by mutual consent" two months before the founding of the Society (*Burlington Hawk Eye*, 11 April 1850). The next we hear of him is a year after the meeting, when he announced that he "has resumed the Practice of Medicine" (*Burlington Hawk Eye*, 19 June 1851). Taken together, these notices suggest that he, like Dillon, may not have been in a position to assist the committee during the year following his appointment.

In his introduction, Rauch acknowledged that not every medicinal species to be found in Iowa was included. This lack of completeness he attributed to two factors. First, there had been very little botanical exploration in Iowa prior to that time, which meant that he could not rely upon existing literature or collections to any significant extent. Second, because Rauch had been in the state a mere three months when the project began, his personal knowledge of its flora was quite meager. As a result, he assembled the information embodied in his report from three sources.

Field studies.—As soon as the 1850 meeting ended, "I endeavored to gain as much information as I possibly could by personal observation, at the same time collecting *all* the indigenous medicinal plants, so that *by the end of the season* I had quite a fine collection. It was my purpose to have presented *duplicates of each* plant to the Society at this meeting" [*italics mine*]. This would seem to imply that every name in the report was documented by one or more herbarium specimens in duplicate, all gathered between mid-June and the close of the 1850 growing season. Localities reported were Burlington, Keokuk, "North part of State," "Lakes N.W. part of

State," "S.W. of state," and the Cedar, Wapsipinicon, and Missouri Rivers, which would imply that Rauch traveled the length and breadth of the state while collecting. In light of the fact that Iowa had not a single mile of operating railroad at that time, this would have been a considerable undertaking.

The enticing prospect that herbarium specimens exist to vouch for this forgotten checklist are dashed as soon as they raised. In the very next sentence, Rauch stated, "unfortunately my specimens were all destroyed." How and when this calamity befell was not indicated, but it must have happened sometime after Rauch identified the specimens, but before he presented the report.

Curiously, it would seem that this was not the only herbarium in Burlington that was destroyed in this period. The Iowa Historical and Geological Institute was an amateur scientific society founded at Burlington in 1843 (Newhall 1846; Jewett 1850; Rhees 1859). According to Parker (1855), its holdings included "an herbarium containing the greater portion of the plants found in the State." All of the Institute's collections were destroyed on 16 January 1853, when the building housing them burned to the ground (Anonymous 1853a, 1853b, 1857b).

The existence in the 1850s of two herbaria in Burlington, both purporting to represent well the flora of the entire state, seems odd. If the Institute's herbarium was in existence when Rauch was preparing his report, why did he not rely on it for information? As a member (Parker 1855; Wilson & Fiske 1900), he would have known about it. One possibility is that there has been some confusion and the herbarium mentioned by Parker (1855) was actually Rauch's, destroyed prior to May 1851. Alternatively, Rauch may have carried out his intention, as stated in the introduction of his report, to rebuild the lost collection "at some future period;" his address to the Southern Iowa Horticultural Society (Rauch 1853) does allude to botanical collecting during the summer of 1852. If this had been done under the aegis of the Institute, he once again would have lost his herbarium when their building burned.

Botanical literature.—Rauch also availed himself of such publications as were available, specifically "the various reports of the Geological and other explorations made of this state by the Government." This might be an allusion to Torrey (1843, 1845), but if so, Rauch did not take up all of the species listed therein. Parry's (1852) full report had not yet been published, though an excerpt had been printed (Parry 1847) and may have been known to Rauch (see below). But again, he did not take up all species listed there. Other government surveys (e.g., Pike 1810; Allen 1814; Lea 1836; Allen 1846) did not contain any formal botany, though the descriptive accounts of Plumbe (1839) and Galland (1840) did list a number of useful plants by their common names.

The literature mentioned by Rauch also included "works of Torry [*sic*] and Gray, Bigelow, Rafinesque, Riddel [*sic*], Eaton, Nuttall, James, Wood, Griffith's Medicinal Botany, and the U.S. Dispensatory of Wood and Bache." The last two (Griffith 1847; Wood & Bache 1836) no doubt were sources for information on medicinal use. Most of the remainder (e.g., Nuttall 1818; Torrey 1824; Eaton & Wright 1840; Gray 1848) likely were used as guides to identification and nomenclature, rather than as documentation for any species' occurrence in Iowa. To the best of my knowledge, the only plants reported from Iowa in such works were *Aster sericeus* and *Prenanthes alba* by Wood (1847), and *Callirhoe triangulata* by Gray (1849); the latter two appear in Rauch's report but not the first. However, the reports of species from the environs of the Missouri River (see above) may have been derived from the literature. Rauch seems to have felt that if Pursh (1814), Nuttall (1818), or James (1823, 1825) reported a species from "the plains of the Missouri" (e.g., *Artemisia santonicum*, Pursh 1814; *Gentiana acuta*, Nuttall 1818), it could be assumed to occur in western Iowa. In fact, these explorers did not encounter such plants until much farther upstream.

Other botanists.—Rauch's third source for his report was information obtained from three other men interested in botany. The first, whom he acknowledged "for much valuable information," was Dr. Edwin James (1797–1861). James was a student of both John Torrey and Amos Eaton (Aldrich 1899; Wood 1955). In 1820, he served as botanist and geologist on Maj. Stephen Long's expedition to explore the Rocky Mountains, where he led the first recorded ascent of Pike's Peak (Goodman & Lawson 1995). Upon completing his report of the expedition (James 1823, 1825; Torrey 1828), he secured an appointment as an assistant surgeon in the Army's medical department (Benson 1968), during which time he assisted John Tanner in publishing his captivity

narrative (James 1830). In 1833 he retired from medicine and three years later settled on a farm southwest of Burlington, where he spent the remainder of his days as an active advocate of abolition and temperance (Frazee 1899; Pammel 1907–08). In the body of his report, Rauch related information that he received from "my friend Dr. James" on the use of *Eupatorium perfoliatum* as malarial prophylaxis, as well as reporting the occurrence of *Trillium nivale* on James' farm.

The second man acknowledged was Alfred Sanders (1819–1865), "who has done much as an amateur botanist toward exploring and collecting the Flora of this State." Sanders was owner, publisher, and editor of *The Davenport Gazette,* which he had founded upon his arrival in 1841 (Gue 1903); it was this newspaper that had published Parry's (1847) summary of his Iowa collecting. "In early life he made botany a specialty, and was very successful in its prosecution. During the first year of his residence in Iowa he spent much time in the prairies and woods making collections of plants, analyzing and classifying them" (Anonymous 1882b). In Parry's (1847) list, Sanders was credited with collecting *Penstemon grandiflorus* Nutt. on the Cedar River, a species not listed by Rauch.

The final man mentioned was David Sylvester Sheldon (1809–1886), who (along with Rauch and Sanders) would "be happy to exchange [plant] specimens with persons of this or any other State." Sheldon was Professor of Natural Science at Iowa College in Davenport, the forerunner of Grinnell College. Here, he spent considerable time "scouring the adjacent country, securing specimens of plants, shells, fossils, etc., which by an extensive system of exchanges, secured valuable returns from all parts of the world" (Parry 1893). During 1852–54, Sheldon was assisted in these efforts by a tutor at the college, Sereno Watson (1826–1892), who later became curator of the Gray Herbarium at Harvard University (Anonymous 1892b). Together they assembled "a very complete series of local plants ... most of which are now stored in the Davenport Academy [of Natural Sciences] Herbarium" (Parry 1893). Sheldon was the first president of that institution (Pratt 1882), which was the forerunner of the Putnam Museum.

Publication.—The report was approved and ordered printed as part of the proceedings of the meeting (Ransom 1851). For each of the 516 species recognized, Rauch provided its binomial (avowedly following Torrey & Gray 1838–43), vernacular name(s), and pertinent synonymy, followed by succinct notes on habitat (including locality in some cases), flower color, phenology, and uses. The species were arranged into 93 orders (families in current usage) "according to the natural method, or that of Jussieu." Sanford (1851) reviewed the finished report favorably:

> The report of our friend Dr. J. H. Rauch, also of the City of Burlington, likewise merits the highest commendation. Dr. H. [*sic*] has the honor of exploring the medical Botany of Iowa, and an attentive examination of his report, will be sufficient to convince any one of the fidelity and zeal with which he has performed his task. We hope his labors will ... constitute a nucleus around which a full collection and classification of our indigenous and naturalized plants may be made.

Subsequent events.—At the conclusion of the Society's 1851 meeting, Rauch and Dr. Moses Cousins, Jr. (1826–1868), were appointed "a standing committee on Medical Botany" (Ransom 1851; Anonymous 1854a). Cousins, a native of Vermont and an 1850 graduate of Cleveland Medical College, had recently set up practice in Albia (Anonymous 1878, Hickenlooper 1896). Like Rauch, Cousins "was a lover of natural science. Botany was a favorite study with him; he delighted in the examination and cultivation of plants, fruit and ornamental trees, vines, etc. ..." (Anonymous 1869). One might wonder why, given these interests, he had not been appointed to the original *ad hoc* committee instead of Brookbank or Dillon. This was almost certainly because he was not among those present at that first meeting (cf. Matthews 1850; Sanford 1850).

Unlike the original committee, its successor seems to have achieved little. At the Society's 1852 meeting, held 5 May in Fairfield, "the Committee on Medical Botany was given further time to report" (Anonymous 1854a). In fact, it appears from the official record that neither Rauch nor Cousins was present that day. A number of committees made reports at the Society's 1853 meeting, held 8 June in Davenport, but there was no mention of the Committee on Medical Botany in the official record (Anonymous 1854a).

The discovery of Cousins' botanical interest and activity in this period may solve a long-standing mystery

involving species attributed to Iowa by Alphonso W. Wood. As noted above, two species were reported from the state in the second edition of his original *Class-book* (Wood 1847); the collector of the vouchers was not indicated. In his all-new *Class-book* (cf. Merrill 1948), however, Wood (1861) indicated that "Dr. Cousens generously supplied us with the plants of the state of Iowa. His name often appears in our pages." Curiously, Wood did not indicate the doctor's first name or initials, or his city of residence, though these were routinely given for his other contributors. Even those species not explicitly credited to Cousens apparently originated with him. In what remains of Wood's herbarium (cf. Arthur 1884, Rusby 1936) is an undated Iowa specimen of *Tomanthera auriculata* (Michx.) Raf. (NY-29001) collected by "Dr. Cousens." Wood (1861) reported this species from Iowa (as *Gerardia auriculata* Michx.) but did not mention Cousens.

I have seen no unequivocal evidence linking Moses Cousins, Jr., of Albia to Wood or his *Class-book*. Nevertheless, I consider him the most likely candidate to have been the mysterious Iowa contributor. The difference in spelling is no real impediment to this assumption, as Wood was well known for his many typographical errors (Meehan 1881). At ten places in the text, including the protologue of *Pyrus coronaria* var. *ioensis* A. Wood (cf. Lammers 1985, 1998), it was spelled as in the introduction: "Cousens." However, under *Marsilea vestita* Hook. & Grev. (cf. Arthur 1884), it was rendered "Couzens." *Veratrum woodii* was one of the ten species credited to "Cousens," but it was attributed to "Cozzens" when the specimen was cited elsewhere (Wood 1878). In only one instance did Wood's spelling conform to the Iowa physician's name. A revised printing (Wood 1869) was created by replacing a few of the stereotyped pages with newly composed printing plates (Merrill 1948). On one such page, *Aster anomalus* Engelm. was reported from Iowa, and credited to "Cousins."

The last evidence we have of Rauch's botanical activities was his speech to the Southern Iowa Horticultural Society (Rauch 1853). A major portion of this address was devoted to urging the membership to cultivate more plants native to Iowa, particularly those "which grow upon our prairie neglected." He took a dim view of those who knew all the fashionable exotics, "but take them into our fields and forests, and they are not able to distinguish one plant from another." He encouraged the group to "be American in our floriculture as well as in government," asserting that, "our lily, moccasin flower, butter-fly weed, orchis, dogbane, and many others will vie for beauty with any that are found in other parts of the world." He indicated that during the preceding summer (i.e., 1852), he had exhibited attractive native plants at the group's monthly meetings in order to foster greater interest in growing them, and intended to do so in the coming season as well. Whether he actually did so is not known.

DECONSTRUCTION OF THE "REPORT"

Before the botanical significance of Rauch's report can be judged, its core information must be brought into conformity with modern practice, so that rational comparisons may be made. For this purpose I have chosen as a standard of reference Eilers and Roosa's (1994) list of Iowa vascular plants. Although additions to the Iowa flora continue to be made (e.g., Lewis 1998; Norris et al. 2001; Cusick 2002; Thompson 2010), it nevertheless offers the single best summary currently available.

Synonymy.—Names employed to denote plants in century-old literature often differ from those used to denote the same entities today. These differences come about for two reasons. First, classifications are hypotheses, not facts (Donoghue 1987; LaDuke 1987). As such, they change over time, as new data and new methods of data analysis become available (Stuessy 2009). When classifications change (e.g., a species is moved to a different genus, or a subspecies is segregated as a distinct species), names will change as well. Second, the botanical community today has a comprehensive and rigorous set of rules for the naming of plants, the *International Code of Botanical Nomenclature* (McNeill et al. 2006). The bestowing of names prior to the Twentieth Century was governed by little more than custom and caprice; such names often find themselves on the wrong side of current rules and must be brought into compliance.

In many cases, a name used by Rauch is a heterotypic (taxonomic) synonym of one in Eilers and Roosa (1994). For example, Paper Birch was called *Betula papyracea* for many years until it was noticed that the name *B. papyrifera* pertained to the very same species but had been published four years earlier. Silver Maple was

called *Acer dasycarpum* during the many years that its correct name, *A. saccharinum*, was erroneously applied to Sugar Maple (*A. saccharum*). Heterotypic synonyms in the list that follows are denoted by the abbreviation "incl." for "including." Each also bears a parenthetical reference to support the name change. In selecting these references, I have given preference to the eight editions of *Gray's Manual* (Gray 1848, 1856, 1862, 1863, 1867; Watson & Coulter 1889; Robinson & Fernald 1908; Fernald 1950), because this work has long been a primary reference in Iowa. In this way, one has a general idea of when botanists in the state would have begun to use the current name.

A name used by Rauch may also be a homotypic (nomenclatural) synonym of one used by Eilers and Roosa (1994). For example, *Aspidium acrostichoides* (Michx.) Sw. is based on the same type (that of *Nephrodium acrostichoides* Michx.) as *Polystichum acrostichoides* (Michx.) Schott. All three pertain to the same biological entity; they merely differ in the genus to which it is assigned. Most such synonyms are obvious from the uniformity of the final epithet and its author, though sometimes this is not the case. Either way, homotypy is indicated by simply citing the synonym alone, with neither "incl." nor reference.

Some differences have resulted from the earlier misapplication of a name to a taxon that does not include the type of that name. Case in point: the erroneous use of *Acer saccharinum* for Sugar Maple instead of Silver Maple noted above. Such misapplied names are not, properly speaking, synonyms; synonyms are created by differing opinions as to the circumscription, position, and/or rank of a taxon, or by ignorance of priority or homonymy (McNeill et al. 2006). These misapplied names simply represent errors of identification that became established and pervasive in the primary literature. They are denoted in the list below by the abbreviation "misappl." for "misapplied," followed by a parenthetical documentary reference. The work of Jones and Fuller (1955) was especially helpful in sorting out misapplied names, by providing insight into how certain names were used by other Midwestern botanists of the day.

Finally, if a name used by Rauch but not by Eilers and Roosa (1994) is neither a synonym nor a misapplication, it must simply represent an error in identification. Ordinarily, such errors are rectified through examination of voucher specimens. With the loss of Rauch's herbarium, disposition of such names becomes problematic. I have attempted to divine what plant Rauch had in hand by considering what other members of the genus or family are present in Iowa that he did *not* report, which might logically be confused with the unlikely species. In doing so, I have borne in mind the state of botanical knowledge in the 1850s, specifically the reference works used by Rauch. In most cases, I am able to suggest a plausible disposition (e.g., the report of *Betula glandulosa* likely based on material of *B. pumila* var. *glandulifera*). In others, the dubious report must be allowed to stand (e.g., *Xanthorhiza simplicissima*).

Format.—In the following analysis of Rauch's checklist, Rauch's Jussieuean arrangement of taxa is replaced by the sequence used in Eilers and Roosa's (1994) list. Nomenclature also follows this standard, unless the name they used is contrary to the *Code* (e.g., *Quercus borealis*, *Salix rigida*). Rauch's name if different follows in brackets; see the preceding section for details on notation. Most of the ancillary information provided by Rauch (flower color, phenology, uses) is omitted; only his statements on habitat and distribution are retained, set off as quotes. Pertinent information from his address to the Southern Iowa Horticultural Society (Rauch 1853) is quoted for a few species.

Species stated by Eilers and Roosa (1994) to be native to Iowa are in Roman type, while non-natives are in Italic. For the latter, the year it was first documented in the state (Cratty 1929) is given. Species *not* listed by Eilers and Roosa are prefaced with an asterisk; italicizing an asterisked name indicates that it is not native to the United States. Statements regarding the geographic distribution of these supernumeraries are derived from Kartesz (2011).

PTERIDOPHYTES

Adiantaceae

Adiantum pedatum L.—"Rocky woods."

Aspleniaceae

Polystichum acrostichoides (Michx.) Schott [*Aspidium acrostichoides* (Michx.) Sw.]—"Bluffs and rocky woods."

Equisetaceae

Equisetum hyemale L.—"Wet places."

GYMNOSPERMS

Cupressaceae

Juniperus virginiana L.—"Found on Red Cedar River."

*Taxodium distichum (L.) Rich. [*Cupressus disticha* L.]—"Wet soils." No nearer than southeastern Missouri or southern Illinois. In his address to the Southern Iowa Horticultural Society, Rauch (1853) said, "Well do I recollect the emotions caused by my seeing the enormous *Cupressus disticha*, planted by Bartram, in his garden near Philadelphia ..." This refers to a tree planted by botanist John Bartram (1699–1777) at his estate on the west bank of the Schuylkill River. Believed to have been transplanted from Florida ca. 1740, the tree attained a height of 175 ft before dying in the 1890s (Williams 1908).

Thuja occidentalis L.—"Border of streams, lakes, &c." Although Eilers and Roosa (1994) did not regard this as native, natural populations are found as near as southeastern Minnesota, southwestern Wisconsin, and northern Illinois.

Pinaceae

Abies balsamea (L.) Mill.—"North part of State."

*Picea mariana (Mill.) Britt., Sterns & Poggenb. [incl. *Abies nigra* (Ait.) Poir. (Watson & Coulter 1889, Robinson & Fernald 1908)]—As near as eastern Minnesota and southwestern Wisconsin.

*Pinus echinata Mill. [incl. *P. variabilis* (Ait.) Lamb. (Gray 1848, Robinson & Fernald 1908)]—"North part of State." No nearer than eastern Missouri or southern Illinois. If it *were* to occur naturally in Iowa, it would be in the southeastern counties, not the north.

*Pinus palustris Mill.—No nearer than northern Louisiana or central Mississippi, though Mead (1846) reported it as planted in adjacent Illinois.

*Pinus resinosa Ait.—"North part of the State." As near as southeastern Minnesota, southwestern Wisconsin, and northern Illinois.

Pinus strobus L.

*Tsuga canadensis (L.) Carr. [*Abies canadensis* (L.) Mill.]—As near as southwestern Wisconsin.

Taxaceae

Taxus canadensis Marsh.—"Shady places."

ANGIOSPERMS: DICOTS

Acanthaceae

Ruellia strepens L.—"Prairies." *Ruellia humilis* Nutt. is far more common in Iowa, but was not treated by Gray (1848).

Aceraceae

Acer negundo L. [*Negundo aceroides* Moench]—"Woods." Reported previously by Parry (1847).

Acer nigrum Michx. f.

Acer rubrum L.—"Low woods. Swamps."

Acer saccharinum L. [incl. *A. dasycarpum* Ehrh. (Robinson & Fernald 1908)]—"Banks of rivers."

Acer saccharum Marsh. [*A. saccharinum* L., misappl. (Robinson & Fernald 1908)]—"Forests."

Acer spicatum Lam.—Referred here is Rauch's report of *A. pensylvanicum* L., a northern species occurring no nearer than Michigan's Upper Peninsula, as the two are very similar in morphology.

Anacardiaceae

Rhus aromatica Ait.—"On Red Cedar river. Hedges."

Rhus glabra L.—"Second Fields, woods, &c."

Rhus typhina L.—"Rocky places."

Toxicodendron radicans (L.) Kuntze [*Rhus radicans* L.].

Toxicodendron rydbergii (Small ex Rydb.) Greene [*Rhus toxicodendron* L., misappl. (Rydberg 1900)]—"Woods."

*Toxicodendron vernix (L.) Kuntze [incl. *Rhus venenata* DC. (Robinson & Fernald 1908)]—"Swamps." As near as southern Minnesota, southwestern Wisconsin, and central Illinois.

Annonaceae

Asimina triloba (L.) Dunal [*Uvaria triloba* (L.) Torr. & A. Gray]—"Banks of streams, near Keokuk."

Apiaceae

Angelica atropurpurea L. [*Archangelica atropurpurea* (L.) Hoffm.]—"Fields. Meadows."

Cicuta maculata L.—"Wet prairies."

Conium maculatum L.—"Introduced. Way-sides, &c." Earliest record 1926 (Cratty 1929).

Daucus carota L.—"Introduced. Fields, roadsides." Earliest record 1891 (Cratty 1929).

*Erigenia bulbosa (Michx.) Nutt.—"Banks of streams." As near as northeastern Missouri and western Illinois.

Eryngium yuccifolium Michx. [*E. aquaticum* L., misappl. (Gray 1856)]—"Wet prairies." Reported previously by Parry (1847).

Heracleum lanatum Michx.—"Low places."

Osmorhiza claytonii (Michx.) C. B. Clarke [*O. brevistylis* DC., nom. illeg.]—"Woods."

Osmorhiza longistylis (Torr.) DC.—"Woods."

Oxypolis rigidior (L.) Raf. [*Archemora rigidior* (L.) DC.]—"Swamps." Reported previously by Parry (1847).

Pastinaca sativa L.—"Introduced. Fields, along fences &c." Earliest record 1895 (Cratty 1929).

Polytaenia nuttallii DC.—"Prairies."

Sanicula marilandica L.—"Woods. Thickets."

Sium suave Walt. [*S. latifolium* L., misappl., and incl. *S. lineare* Michx. (Jones & Fuller 1955)]—"Swamps &c."

Apocynaceae

Apocynum androsaemifolium L.—"Hedges and fields."

Apocynum cannabinum L.—"Waste lands."

Aquifoliaceae

Ilex verticillata (L.) A. Gray [*Prinos verticillatus* L.]—"Shrub swamps."

Araliaceae

Aralia nudicaulis L.—"Woods."

Aralia racemosa L.—"Woods."

*Aralia spinosa L.—"Woods." No nearer than southeastern Missouri or southern Illinois as a native plant, though reported as an escape from cultivation in Johnson County by Fitzpatrick (1899).

Panax quinquefolius L.—"Woods."

*Panax trifolius L.—"Low woods." As near as southwestern Wisconsin.

Aristolochiaceae

*Aristolochia macrophylla Lam. [incl. *A. sipho* L'Hér. (Robinson & Fernald 1908)]—No nearer than central Kentucky, West Virginia, or western Pennsylvania, though not infrequently cultivated.

Aristolochia serpentaria L.—"Thickets."

Asarum canadense L.—"Rich soil."

Asclepiadaceae

Asclepias amplexicaulis Sm. [incl. *A. obtusifolia* Michx. (Robinson & Fernald 1908)].

Asclepias incarnata L.—"Wet places."

Asclepias quadrifolia Jacq.

Asclepias syriaca L. [*A. cornuti* Decne., nom. illeg.]—"Low shady grounds."

Asclepias tuberosa L.—"Sandy places."

Asteraceae

Achillea millefolium L.—"Fields."

Anthemis arvensis L.—"Introduced. Fields."

Anthemis cotula L. [*Maruta cotula* (L.) DC.]—"Introduced. Roadsides." Earliest record 1881 (Cratty 1929).

Arctium lappa L. [*Lappa major* Gaertn.]—"Waste grounds." *Arctium minus* (Hill) Bernh. is far more common in Iowa, but was not treated by Gray (1848).

Artemisia biennis Willd.—Reported previously by Torrey (1843, 1845).

Artemisia campestris L. subsp. caudata (Michx.) H. M. Hall & Clements [*A. canadensis* Michx., misappl. (Jones & Fuller 1955)]—"Lakes N.W. part of State."

Artemisia dracunculus L. [incl. *A. dracunculoides* Pursh (Barkley et al. 2006)]—Rauch's report of *A. santonicum* L. from "Banks of Mo." is referred here also. This is a Eurasian species not known to have ever occurred in North America (Barkley et al. 2006), which may have been included on authority of Pursh (1814). Pursh's report of *A. santonicum* from "the plains of the Missouri" was based upon a specimen from the Lewis and Clark expedition, although no specimen unequivocally tied to that report can now be located (Meehan 1898, Reveal et al. 1999). The name *A. lewisii* Torr. & A. Gray was published (Torrey & Gray 1838–43) for this misidentified plant, and on the basis of its description, Reveal et al. (1999) treated the name as a synonym of *A. dracunculus*.

Conyza canadensis (L.) Cronq. [*Erigeron canadensis* L.]—"Fields."

Dyssodia papposa (Vent.) A. S. Hitchc. [*D. chrysanthemoides* (Willd.) Lag., nom. illeg.]—"Streets." Reported previously by Parry (1847).

Echinacea purpurea (L.) Moench—"Thickets."

Erigeron annuus (L.) Pers. [incl. *E. heterophyllum* Muhl. ex Willd. (Gray 1848)]—"Woods, Fields."

Erigeron philadelphicus L.—"Woods."

Eupatorium altissimum L.—"Woods."

*Eupatorium fistulosum Barratt—"Thickets." As near as northeastern Missouri and western Illinois.

Eupatorium maculatum L.—"Low grounds."

Eupatorium perfoliatum L.—"Prairies."

Eupatorium purpureum L.—"Prairies, woods."

Eupatorium rugosum Houtt. [*E. ageratoides* L. f.]—"Woods."

Helenium autumnale L.—"Wet prairies."

Inula helenium L.—"Introduced ... Roadsides." Earliest record 1895 (Cratty 1929).

Krigia biflora (Walt.) Blake [*Hieracium venosum* L., misappl. (Jones & Fuller 1955)]—"Woods."

Lactuca canadensis L. [incl. *L. elongata* Muhl. ex Willd. (Gray 1867)]—"Hedges, Thickets."

Liatris pycnostachya Michx.—"Prairies." Referred here is Rauch's report of *L. spicata* (L.) Willd., a species of very scattered occurrence in southern Wisconsin, Illinois, and southeastern Missouri. The two species are very similar in overall appearance, and *L. pycnostachya* was not treated by Gray (1848).

Liatris squarrosa (L.) Michx.

Parthenium integrifolium L.—"Prairies."

*Petasites palmatus (Ait.) A. Gray [*Nardosmia palmata* (Ait.) Hook.]—"Swamps." No nearer than central Minnesota and central Wisconsin.

Prenanthes alba L. [*Nabalus albus* (L.) Hook.]—"Woods." Reported previously by Wood (1847).

Senecio aureus L.—"Woods, Meadows."

Senecio vulgaris L.—"Introduced. Waste grounds."

Silphium laciniatum L.—"Prairies." Reported previously by Parry (1847).

Silphium perfoliatum L.—"Prairies." Reported previously by Parry (1847).

Silphium terebinthinaceum Jacq.

Solidago nemoralis Ait. [*Solidago odora* Ait., misappl. (Jones & Fuller 1955)]—"Woods, hills."

Solidago rigida L.—"Prairies." Reported previously by Parry (1847).

Tanacetum vulgare L.—"Introduced. Fields, roadsides." Earliest record 1893 (Cratty 1929).

Taraxacum officinale F.H. Wigg. [incl. *T. dens-leonis* Desf. (Watson & Coulter 1889)]—"Fields, &c." Earliest record 1873 (Cratty 1929).

Vernonia fasciculata Michx.—"Woods and prairies."

Vernonia missurica Raf. [*V. noveboracensis* Willd., misappl. (Jones & Fuller 1955)]—"Wet prairies."

Berberidaceae

Berberis vulgaris L.—"Gardens." Earliest record 1892 (Cratty 1929).

Jeffersonia diphylla (L.) Pers.—"Woods."

Podophyllum peltatum L.—"Woods."

Betulaceae

*Alnus serrulata (Ait.) Willd. [*A. rubra* Bong., misappl. (Furlow 1979)]—"Swamps." As near as northeastern Missouri.

Betula alleghaniensis Britt. [*B. excelsa* Ait., misappl. (Gray 1867; Furlow 1997)].

Betula nigra L.—"Banks of streams."

Betula papyrifera Marsh. [incl. *B. papyracea* Ait. (Watson & Coulter 1889)]—"Woods N. part of State."

Betula pumila L. var. glandulifera Regel—Referred here is Rauch's report of *B. glandulosa* Michx., an arctic species with disjunct populations in the Black Hills of South Dakota and northern New England. Both are dwarf shrubs with small leaves and numerous glands.

Carpinus caroliniana Walt.—"Bluffs around Burlington."

Corylus americana Walt.

Ostrya virginiana (Mill.) K. Koch

Bignoniaceae

Catalpa bignonioides Walt.

Boraginaceae

Cynoglossum officinale L.—"Roadsides." Earliest record 1895 (Cratty 1929).

*Cynoglossum virginianum L.—"Wood." No nearer than eastern Missouri or southern Illinois. In Rauch's day, it encompassed populations later segregated as *C. boreale* Fern., a northern species that comes no closer than central Minnesota or central Wisconsin.

Lithospermum arvense L.—"Fields."

Lithospermum canescens (Michx.) Lehm.—"Prairies."

Mertensia virginica (L.) Pers. ex Link—"Bottoms."

**Symphytum officinale* L.—"Introduced. Gardens, low grounds." Eurasian cultigen.

Brassicaceae

Armoracia rusticana P. Gaertn., B. Mey. & Scherb. [*Cochlearia armoracia* L.]—"Introduced ... Garden." Earliest record 1895 (Cratty 1929).

Brassica nigra (L.) W.D.J. Koch [*Sinapis nigra* L.].—"Introduced." Earliest record 1891 (Cratty 1929).

*Dentaria diphylla Michx.—"Woods." As near as southwestern Wisconsin. Isaiah Reid (1836–1911), who graduated from Yellow Springs College in nearby Kossuth in 1861 (Kerwin 2006), told Bessey (1871) that he had collected this in the Burlington vicinity, while Fitzpatrick (1899) reported an 1882 specimen from Hancock County.

Dentaria laciniata Muhl. ex Willd.—"Woods."

Draba nemorosa L. [*D. nemoralis* Ehrh., misappl. (Fernald 1934)].

Draba reptans (Lam.) Fern. [*D. caroliniana* Walt., misappl. (Fernald 1934)]—"Fields."

*Erysimum capitatum (Dougl. ex Hook.) Greene [incl. *E. arkansanum* Nutt. (Rollins 1993)]—Al-Shehbaz (2010) did include Iowa in this species' range, but stated that it is a western species that "has been collected only sporadically" east of the Great Plains.

Nasturtium officinale R. Br.—"Brooks and Ponds … Cultivated as a salad." Earliest record 1893 (Cratty 1929).

Rorippa palustris (L.) Bess. [*Nasturtium palustre* (L.) DC.].

Sisymbrium officinale (L.) Scop.—"Fields &c." Earliest record 1881 (Cratty 1929).

Cactaceae

Opuntia humifusa (Raf.) Raf. [*O. vulgaris* Mill., misappl. (Fernald 1950)]—"Sandy places."

Campanulaceae

Lobelia cardinalis L.—"Meadows."

Lobelia inflata L.—"Woods."

Lobelia siphilitica L.—"Along streams."

Caprifoliaceae

*Lonicera flava Sims—"Cultivated for its beauty and fragrance." Native to the southern states. Listed without comment by Arthur (1876).

Sambucus canadensis L.—"Thickets."

Sambucus racemosa L. subsp. pubens (Michx.) House [*S. pubens* Michx.].

Triosteum perfoliatum L.—"Woods."

*Viburnum acerifolium L.—"Woods." As near as southwestern Wisconsin, and recently collected in northeastern Iowa (D. Q. Lewis, pers. comm.).

Viburnum lentago L.—"Banks of streams."

Viburnum prunifolium L.—"Woods."

Viburnum trilobum Marsh. [incl. *V. opulus* L. var. *americana* Ait. (Fernald 1950)]—"Banks of streams. N. part of State."

Caryophyllaceae

Saponaria officinalis L.—"Introduced." Earliest record 1894 (Cratty 1929).

Silene virginica L.—"Fields." Although Eilers and Roosa (1994) regarded this as non-native, natural populations occur as near as southwestern Wisconsin, western Illinois, and northeastern Missouri.

Celastraceae

Celastrus scandens L.—"Climbing shrub in woods and thickets, on trees ... Often planted as an ornamental shrub."

*Euonymus americanus L.—"Woods." No nearer than eastern Missouri or eastern Illinois.

Euonymus atropurpureus Jacq.—Reported previously by Torrey (1843, 1845) and Parry (1847).

Chenopodiaceae

Chenopodium ambrosioides L. [incl. *C. anthelminticum* L. (Gray 1856)]—"Prairies." Earliest record 1905 (Cratty 1929).

Chenopodium botrys L.—"Sandy fields." Earliest record 1894 (Cratty 1929).

Cistaceae

Helianthemum canadense (L.) Michx.—"Fields. Woods."

Hudsonia tomentosa Nutt.—"Shores of lakes N. part of State."

Convolvulaceae

Ipomoea batatas (L.) Lam. [*Convolvulus batatas* L.]—"Introduced." Cultigen of Central American origin.

Ipomoea jalapa (L.) Pursh [*Convolvulus jalapa* L.]—"Sandy places … Mistaken at one time for the officinal Jalap [i.e., *I. purga* (Wender.) Hayne]." Native of Mexico and Central America.

Ipomoea lacunosa L. [*Convolvulus lacunosus* (L.) Spreng.]—"Hills."

Ipomoea pandurata (L.) G. F. W. Mey. [*Convolvulus panduratus* L.]—"Sandy places."

Cornaceae

Cornus amomum Mill. subsp. obliqua (Raf.) J. S. Wilson [*C. sericea* L., misappl. (Robinson & Fernald 1908)].

Cornus canadensis L.

Cornus foemina Mill. subsp. racemosa (Lam.) J. S. Wilson [incl. *C. paniculata* L'Hér. (Fernald 1950)].

Cornus rugosa Lam. [incl. *C. circinata* L'Hér.; Fernald (1950)].

Cornus stolonifera Michx.—"Woods."

*Nyssa sylvatica Marsh. [incl. *N. multiflora* Wang. (Watson & Coulter 1889)]—"Woods." No nearer than southeastern Missouri or eastern Illinois.

Cucurbitaceae

Cucurbita pepo L. [incl. *C. verrucosa* L. (Whitaker 1947)]—"Cultivated by Indians west of Miss. Nutt." This seemingly is a reference to Nuttall (1818), who stated that *C. verrucosa* was "Cultivated also by the Indians of the Missouri to its sources." Cultigen of Central American origin.

Droseraceae

Drosera rotundifolia L.—"Swamps." Pammel (1909) specifically stated that this, like *Sphagnum*, did not occur in Iowa's bogs; the discovery of both was reported by Grant and Thorne (1955).

Ericaceae

Arctostaphylos uva-ursi (L.) Spreng.—"Shrub sandy places N. part of State."

*Chimaphila maculata Pursh—"Sandy woods." No nearer than northeastern Illinois.

Chimaphila umbellata (L.) W. P. C. Barton—"Woods. N. part of State."

*Gaultheria hispidula (L.) Muhl. ex Bigel. [*Chiogenes hispidula* (L.) Torr. & A. Gray]—"Shady woods." No nearer than central Minnesota or central Wisconsin.

*Gaultheria procumbens L.—"Woods." As near as central Minnesota, southwestern Wisconsin, and northern Illinois.

Gaylussacia baccata (Wang.) K. Koch [incl. *Vaccinium resinosum* Ait. (Watson & Coulter 1889)]—"Woods."

*Vaccinium corymbosum L. [incl. *V. virgatum* Ait. (Tucker 2009)]—"Swamps ... Woods." As near as northern Illinois.

*Vaccinium macrocarpon Ait. [*Oxycoccus macrocarpon* (Ait.) Pers.]—"Sphagnous swamps." As near as southern Minnesota and southwestern Wisconsin.

*Vaccinium oxycoccos L. [*Oxycoccus palustris* Pers.]—"Swamps. N. part of State." As near as central Minnesota and southwestern Wisconsin. Regarding this and the preceding, Galland (1840) reported that "Cranberries grow in the greatest abundance in the northern parts of the Territory, and are obtained from the Indians by the traders in large quantities." However, as described in an earlier section of his book, Iowa Teritory at that time extended north all the way to the Canadian border.

*Vaccinium stamineum L.—"Dry Woods." No nearer than southern Missouri or southern Illinois.

Euphorbiaceae

Acalypha virginica L.—"In dry soils."

Euphorbia corollata L.—"Dry sandy soil." Reported previously by Parry (1847).

*Euphorbia ipecacuanhae L.—"Sandy places." No nearer than northern Virginia.

**Euphorbia lathyris* L.—"Gardens." Eurasian cultigen.

Euphorbia marginata Pursh—"Gardens."

**Ricinus communis* L.—"Cultivated ... This plant thrives well here with a little care, and I have no doubt that it would well pay the farmer for his trouble." Eurasian cultigen.

Fabaceae

Amorpha canescens Pursh—"Thought to prefer localities where lead exists." Reported previously by Parry (1847). Parry (1852) explained this reputation as a predictor of mineral deposits thusly: "It attaches itself with most luxuriance to rocky crevices and spots about which the peculiar dry earth, indicating a mineral vein, exists, and the miner is thus guided in making his excavations. Farther than this any definite relation with the lead-bearing rock is sufficiently disproved by the extensive geographical range of this plant." In his address to the Southern Iowa Horticultural Society, Rauch (1853) said, "... on our elevated and sandy prairies, we have ... *Amorpha canescens*, the flower of which will vie for beauty with the cactus that they take so much pains to cultivate ... I have no doubt if it were generally known ... it would have ere this received their attention, and occupied a prominent place in their gardens."

Apios americana Medik. [*A. tuberosa* Moench]—"Woods."

Baptisia lactea (Raf.) Thieret [incl. *B. leucantha* Torr. & A. Gray (Isely 1981)]—"Prairies." Reported previously by Parry (1847).

Baptisia tinctoria (L.) R. Br.

Cassia marilandica L.

Cercis canadensis L.

Chamaecrista fasciculata (Michx.) Greene [incl. *Cassia chamaecrista* L., nom. rej. (Irwin & Barneby 1982)]—"Dry prairies." Reported previously by Parry (1847).

Glycyrrhiza lepidota Pursh—"Banks of Miss."

Gymnocladus dioicus (L.) K. Koch [*G. canadensis* Lam.]—"Rare." Reported previously by Parry (1847).

Pediomelum esculentum (Pursh) Rydb. [*Psoralea esculenta* Pursh]—"Wabsepinecon [Wapsipinicon] river." The stated locality is somewhat puzzling, as this species' distribution in Iowa is almost entirely restricted to the western counties (Eilers & Roosa 1994).

Robinia pseudoacacia L.—Earliest record 1895 (Cratty 1929).

Trifolium pratense L.—"Intro." Earliest record 1880 (Cratty 1929).

Trifolium reflexum L.

Trifolium repens L.—"Pasturage." Earliest record 1892 (Cratty 1929).

*Trifolium stoloniferum Muhl. ex Eat.—Known today from only scattered localities in Missouri, Indiana, Ohio, Kentucky, and West Virginia (Melius 2010), though its documented range included eastern Kansas, northern Arkansas, and southern Illinois (Brooks 1983). Reported without comment by Arthur (1876), and from Woodbury County by Fitzpatrick (1899).

Fagaceae

*Fagus grandifolia Ehrh. [*F. sylvatica* L., misappl. (Gray 1848)]—"Forests." No nearer than eastern Wisconsin, eastern Illinois, or southeastern Missouri.

Quercus alba L.

Quercus bicolor Willd.

Quercus ×bushii Sarg.—Referred here is Rauch's report of *Q. ilicifolia* Wang.; this species of the Middle Atlantic states occurs no closer than western Pennsylvania. Of all Iowa's oaks, this hybrid (which is not infrequent in the southeastern counties; Cooperrider 1957) is the only one which resembles *Q. ilicifolia* in its scraggly habit and lobed wedge-shaped leaves.

Quercus imbricaria Michx.

Quercus macrocarpa Michx.

Quercus marilandica Muenchh. [*Q. nigra* L., misappl. (Robinson & Fernald 1908)].

Quercus muhlenbergii Engelm.—Rauch's reports of *Q. prinus* L., nom. rej., and *Q. montana* Willd. are both referred to this species, the only chestnut oak in Iowa of arboreal stature; as he states "timber valuable" for *Q. prinus* and "ship building" for *Q. montana*, it is unlikely that either report is referable to *Q. prinoides* Willd., Iowa's other chestnut oak, as it is a colonial shrub. *Quercus montana* is an eastern species, occurring no closer than southeastern Missouri and southern Illinois, while the name *Q. prinus* has been applied to both *Q. montana* and to *Q. michauxii* Nutt., another eastern species that comes no nearer than southeastern Missouri and southern Illinois (Nixon 1997).

Quercus palustris Muenchh.

Quercus rubra L.—Eilers and Roosa (1994) used the name *Q. borealis* Michx. f., dismissing *Q. rubra* as "nom. ambig.", but that usage cannot stand (Nixon 1997).

Quercus stellata Wang.

Quercus velutina Lam. [incl. *Q. tinctoria* W. Bartr. (Robinson & Fernald 1908)]

Gentianaceae

*Frasera caroliniensis Walt.—"Moist woods." No nearer than southeastern Missouri or central Illinois.

Gentiana andrewsii Griseb.—Rauch's report of *G. pneumonanthe* L., a Eurasian species, is referred here. Gray (1856) indicated that the plants he had called *G. pneumonanthe* earlier (Gray 1848) were actually *G. linearis* Froel. [as *G. saponaria* L. var. *linearis* (Froel.) Griseb.; cf. Watson & Coulter 1889]. That northeastern species, occurring no nearer than the Upper Peninsula of Michigan, somewhat resembles *G. andrewsii* in shape and color of the corolla.

Gentiana puberulenta J. Pringle—Referred here is Rauch's report of *G. saponaria* L., a southeastern species that occurs as near as northern Illinois; Gray's (1848) circumscription of that species included *G. puberula* Michx., the name mistakenly applied to *G. puberulenta* prior to Pringle (1966).

*Gentianella amarella (L.) Börner [incl. *Gentiana acuta* Michx. (Watson & Coulter 1889)]—"Plains of the Missouri." No nearer than eastern North Dakota or northwestern Minnesota. Report perhaps derived from Nuttall (1818), who reported it "on the plains of the Missouri, near Fort Mandan."

Gentianella quinquefolia (L.) Small [*Gentiana quinquefolia* L.]—"Woods."

*Sabatia angularis (L.) Pursh—"Wet prairies." As near as northeastern Missouri and western Illinois. This could be a misidentification of *S. campestris* Pursh (reported from eastern Iowa by Roosa & Eilers 1994); that species was not included by Gray (1848).

Geraniaceae

Geranium carolinianum L.—"Fields."

Geranium maculatum L.—"Woods."

Hamamelidaceae

Hamamelis virginiana L.

Hippocastanaceae

Aesculus glabra Willd.—"Bottoms. Universal." Reported previously by Parry (1847).

Hypericaceae

*Hypericum adpressum Raf. ex W. Bartr.—As near as western Illinois.

Hypericum canadense L.
Hypericum perforatum L.—"Introduced." Earliest record 1918 (Cratty 1929).
Hypericum prolificum (Spach) Steud.
Hypericum punctatum Lam. [incl. *H. corymbosum* Muhl. ex Willd. (Robinson & Fernald 1908)].
Hypericium pyramidatum Ait.—"Hills. Banks of streams." Reported previously by Parry (1847).

Juglandaceae

Carya cordiformis (Wang.) K. Koch [incl. *C. amara* (Michx. f.) Nutt. ex Ell. (Robinson & Fernald 1908)].
*Carya glabra (Mill.) Sweet [incl. *C. porcina* Nutt. ex Ell. (Robinson & Fernald 1908)]—As near as northeastern Missouri and western Illinois. Three sheets from Story and Webster Counties have recently come to light at ISC, though their status as planted or native is unclear from their labels (D. Q. Lewis, pers. comm.).
Carya laciniosa (Michx. f.) Loud. [incl. *C. sulcata* Nutt. (Robinson & Fernald 1908)]—"Along rivers."
Carya ovata (Mill.) K. Koch [incl. *C. alba* (L.) Nutt., nom. rej. (Robinson & Fernald 1908)].
Juglans cinerea L.—"Bluffs and woods."
Juglans nigra L.—"Forests."

Lamiaceae

Blephilia hirsuta (Pursh) Benth.—"Woods."
*Cunila origanoides (L.) Britt. [*C. mariana* L., nom. illeg.]—"Dry woods." As near as eastern Missouri and western Illinois.
Glechoma hederacea L. [*Nepeta glechoma* Benth.]—"Hedges, &c." Earliest record 1881 (Cratty 1929).
Hedeoma pulegioides (L.) Pers.—"Prairies, fields."
Leonurus cardiaca L.—"Introduced. Waste places." Earliest record 1887 (Cratty 1929).
Lycopus americanus Muhl. ex W. P. C. Barton [incl. *L. sinuatus* Ell. (Robinson & Fernald 1908)]—"Wet places."
Lycopus virginicus L.—"Wet soil."
Marrubium vulgare L.—"Introduced ... Roads, fields." Earliest record 1914 (Cratty 1929).
**Melissa officinalis* L.—"Introduced. Woods and gardens." Eurasian cultigen.
Mentha arvensis L. [incl. *M. canadensis* L. (Robinson & Fernald 1908)]—"Low places."
Mentha ×piperita L.—"Gardens, &c." Earliest record 1903 (Cratty 1929).
Mentha spicata L. [incl. *M. viridis* (L.) L. (Robinson & Fernald 1908)]—"Wet soils." Earliest record 1896 (Cratty 1929).
Monarda fistulosa L.—"Thickets, &c."
Monarda punctata L.
Nepeta cataria L.—"Introduced. Old buildings, &c." Earliest record 1884 (Cratty 1929).
**Origanum vulgare* L.—"Thickets." Eurasian cultigen, sporadically naturalized in the United States, as near as northeastern Illinois.
Prunella vulgaris L.—"Prairies."
*Pycnanthemum incanum (L.) Michx.—"Rocky Woods." No nearer than southern Illinois.
Pycnanthemum pilosum Nutt.—"Low grounds."
Scutellaria incana Biehler [incl. *S. canescens* Nutt. (Fernald 1950)].
*Scutellaria integrifolia L.—"Dry places." No nearer than northern Arkansas or western Kentucky. Based on habitat, the report could be referable to *S. leonardii* Epling.
Scutellaria lateriflora L.—"Low prairies."
Scutellaria nervosa Pursh—"Banks of streams."
Scutellaria ovata Hill [incl. *S. cordifolia* Muhl. ex Benth., nom. illeg. (Epling 1942)].
Scutellaria parvula Michx.—"Prairies." Reported previously by Parry (1847).

Lauraceae

*Lindera benzoin (L.) Blume [*Benzoin odoriferum* Nees]—"Moist woods." As near as northeastern Missouri and western Illinois; reported from "Southern Iowa" by Parry (1852).
Sassafras albidum (Nutt.) Nees [*S. officinale* Nees & C. H. Ebermaier, misappl. (Fernald 1950)]—"Forests, bluffs near Keokuk."

Linaceae

Linum medium (Planch.) Britt. var. texanum (Planch.) Fern.—"Woods." Referred here is Rauch's report of *L. virginianum* L., a species coming as near as central Missouri and western Illinois. Both are perennials with yellow corollas and depressed-globose fruits.
Linum usitatissimum L.—"Introduced ... The cultivation of this plant deserves the attention of our farmers, as there is no doubt it would well repay their trouble." Earliest record 1895 (Cratty 1929).

Loganiaceae

*Spigelia marilandica (L.) L.—"Woods." No nearer than southeastern Missouri or southern Illinois.

Lythraceae

Cuphea viscosissima Jacq.—"Wet grounds."
Lythrum alatum Pursh—"Damp grounds."
Rotala ramosior (L.) Koehne [incl. *Ammannia humilis* Michx. (Watson & Coulter 1889)]—"Wet places."

Malvaceae

Callirhoe triangulata (Leavenw.) A. Gray [incl. *Malva houghtonii* Torr. & A. Gray (Gray 1849)]—"Prairies." Rauch's inclusion of both *C. triangulata* and *M. houghtonii* likely was due to confusion occasioned by the changing treatment of these plants in Rauch's primary references. Torrey & Gray (1838–43) recognized *M. houghtonii*, but included *M. triangulata* Leavenw. (the basionym of *C. triangulata*) within *M. papaver* Cav., a southern species. Subsequently, Gray (1848, 1849) segregated *M. triangulata* from *M. papaver* (assigning *M. houghtonii* to it as a synonym) and specifically reported the species from Iowa.
Malva neglecta Wallr. [*M. rotundifolia* L., nom. rej., misappl. (Fernald 1950)]—"Naturalized. Common." Earliest record 1890 (Cratty 1929).
Malva sylvestris L.—"Naturalized. Fields, gardens." Earliest record 1893 (Cratty 1929).
Napaea dioica L.—"Rich calcareous soil."

Melastomataceae

Rhexia virginica L.—"Wet grounds."

Menispermaceae

Menispermum canadense L.—"Woods."

Menyanthaceae

Menyanthes trifoliata L.—"Swamps, &c."

Moraceae

Cannabis sativa L.—"Introduced ... Cultivated for the sake of its fibre ... The cultivation of hemp should engage the attention of our farmers as it thrives well, and the cultivator is amply remunerated for his trouble, such is the experience of Mr. Williams of Burlington." Earliest record 1894 (Cratty 1929).
Humulus lupulus L.—"Hedges ... Cultivated for the sake of its fertile aments, which are used as a preservative in beer. This is also well worthy of the attention of our farmers."
Maclura pomifera (Raf.) C. K. Schneid. [incl. *M. aurantiaca* Nutt. (Robinson & Fernald 1908)]—"Cultivated for hedges. Thrives well." Earliest record 1892 (Cratty 1929).
Morus rubra L.

Myricaceae

*Comptonia peregrina (L.) J. M. Coult. [incl. *C. asplenifolia* (L.) L'Hér. ex Ait. (Fernald 1950)]—"Woods and hills." As near as northeastern Minnesota, southwestern Wisconsin, and northern Illinois.

Nymphaeaceae

Nelumbo lutea Willd.—"Bottoms, N. and E. of Burlington and S. W. of Keokuk." In his address to the Southern Iowa Horticultural Society, Rauch (1853) stated, "Many will no doubt be surprised when I say that we have a rival in *Nelumbium luteum* [*sic*], for the famous *Victoria regia*; it is found growing in the waters of our own Mississippi, and I have no doubt would be as all other plants could be greatly improved by cultivation. ... while the *Victoria regia* only gives pleasure to the sight and calls forth our admiration, the *Nelumbium luteum* [*sic*], helps to nourish and sustain the life of the wandering Indian ..."

Nuphar lutea (L.) Sibth. & Sm. subsp. variegata (Engelm. ex Durand) E. O. Beal [*N. advena* (Ait.) Ait. f., misappl. (Wiersema & Hellquist 1997)].

Nymphaea tuberosa Paine—"Pond's [*sic*]." Referred here is Rauch's report of *N. odorata* Ait. The two are treated by Wiersema and Hellquist (1997) as conspecific subspecies and Iowa's plants assigned to *N. odorata* subsp. *tuberosa* (Paine) Wiersma & Hellquist.

Oleaceae

Fraxinus americana L.—"North part of State."

Fraxinus nigra Marsh. [incl. *F. sambucifolia* Lam. (Robinson & Fernald 1908)]—"Swamps. North part of State."

Fraxinus quadrangulata Michx.—"Woods."

Onagraceae

Epilobium angustifolium L.—"Meadows."

Epilobium coloratum Biehler.

Epilobium leptophyllum Raf. [*E. palustre* L., misappl. (Fernald 1950)].

Gaura biennis L.

Oenothera biennis L.

Oenothera laciniata Hill [*O. sinuata* L., misappl. (Robinson & Fernald 1908)].

*Oenothera macrocarpa Nutt.—[incl. *O. missouriensis* Sims (Wagner 1980)]. No nearer than southeastern Nebraska, northeastern Kansas, central Missouri, or southern Illinois.

Oenothera pilosella Raf. [*O. fruticosa* L., misappl. (Jones & Fuller 1955)].

Orobanchaceae

Conopholis americana (L.) Wallr. [*Orobanche americana* L.]—"Woods."

*Epifagus virginiana (L.) W. P. C. Barton—"Parasite." No nearer than eastern Wisconsin, eastern Illinois, or southeastern Missouri.

Orobanche uniflora L.—"Woods."

Oxalidaceae

*Oxalis montana Raf. [*O. acetosella* L., misappl. (Fernald 1950)]—"Woods and shady places." No nearer than central Wisconsin.

Oxalis stricta L.—"Fields."

Oxalis violacea L.—"Rocky woods."

Papaveraceae

Argemone polyanthemos (Fedde) G. B. Ownbey—"Banks of streams. S.W. of state." Referred here is Rauch's report of *A. mexicana* L., under the assumption that the discussions of James (1823) and/or Torrey (1828) were responsible for its inclusion (cf. Goodman & Lawson 1995).

Chelidonium majus L.—"Introduced. Fences, roadsides." Earliest record 1928 (Cratty 1929).

Corydalis aurea Willd.—"Woods."

Dicentra canadensis (Goldie) Walp. [*Diclytra canadensis* (Goldie) DC., nom. rej. et illeg.]—"Woods. Rocky."

Dicentra cucullaria (L.) Bernh. [*Diclytra cucullaria* (L.) DC., nom. rej.]—"Woods."

Fumaria officinalis L.—"Fields, gardens."

Sanguinaria canadensis L.—"Woods."

*Stylophorum diphyllum (Michx.) Nutt. [*Mecanopsis diphylla* (Michx.) DC.]—"Woods." As near as eastern Missouri and southern Illinois.

Phytolaccaceae

Phytolacca americana L. [incl. *P. decandra* L. (Fernald 1950)]—"Roadsides, fields."

Plantaginaceae

Plantago major L.—"Fields, &c."

Platanaceae

Platanus occidentalis L.—"Banks of rivers."

Polemoniaceae

Polemonium reptans L.—"Banks of streams, near Burlington."

Polygalaceae

*Polygala paucifolia Willd.—"Woods and Swamps." No nearer than eastern Minnesota, central Wisconsin, or northeastern Illinois. Reported by Thorne (1953) on the basis of a specimen collected in Linn County by George Berry (Meyer 1959).

Polygala polygama Walt.—"Fields, pastures."

Polygala senega L.—"Woods ... Prairies."

Polygonaceae

Fagopyrum esculentum Moench [*Polygonum fagopyrum* L.]—Earliest record 1898 (Cratty 1929).

Polygonum amphibium L.—"Marshes."

Polygonum aviculare L.—"Fields."

Polygonum convolvulus L.—Earliest record 1890 (Cratty 1929).

Polygonum erectum L.—"Fields."

Polygonum lapathifolium L.—"Ditches."

Polygonum persicaria L.—"Wet grounds." Earliest record 1888 (Cratty 1929).

Polygonum punctatum Ell.—"Low grounds."

Polygonum sagittatum L.

Polygonum scandens L.

Polygonum virginianum L.—"Shades."

Rumex acetosella L.—"Pastures, waste grounds." Earliest record 1888 (Cratty 1929).

Rumex altissimus A. Wood—"Wet prairies."

Rumex crispus L.—"Introduced. Cultivated grounds." Earliest record 1879 (Cratty 1929).

Rumex obtusifolius L.—"Fields, waste places." Earliest record 1888 (Cratty 1929).

Rumex occidentalis S. Wats. [R. aquaticus L., misappl. (Rechinger 1937)]—"Ponds."

Rumex orbiculatus A. Gray [R. britannica L., misappl. (Fernald 1950)]—"Muddy places."

**Rumex sanguineus* L.—"Fields." Eurasian species.

Portulacaceae

Portulaca oleracea L.—"Introduced. Indigenous on the Missouri. Gardens." Earliest record 1888 (Cratty 1929). The statement regarding native status farther west was likely derived from Nuttall (1818), James (1823), Torrey (1828), and/or Torrey and Gray (1838–43).

Ranunculaceae

Actaea pachypoda Ell. [incl. *A. alba* (L.) Mill., nom. rej. (Whittemore & Parfitt 1997)]—"Woods."

Actaea rubra (Ait.) Willd.—"Indians."
Anemone canadensis L. [*A. pensylvanica* L., misappl. (Robinson & Fernald 1908)]—"Rocky place."
Anemone cylindrica A. Gray. Reported previously by Parry (1847).
Anemone quinquefolia L. [*A. nemorosa* L., misappl. (Robinson & Fernald 1908)]
Anemone virginiana L.—"Woods."
Aquilegia canadensis L.—"Rocks."
Caltha palustris L.—"Wet meadows."
Cimicifuga racemosa (L.) Nutt.—"Woods."
Clematis occidentalis (Hornem.) DC. [incl. *C. verticillaris* DC. (Whittemore & Parfitt 1997)]—"Woods."
Clematis pitcheri Torr. & A. Gray [*C. viorna* L., misappl. (Jones & Fuller 1955)]—"Woods."
Clematis virginiana L.—"Fences, &c."
*Coptis trifolia (L.) Salisb.—"Swamps north part of state." As near as southern Minnesota and southwestern Wisconsin.
Delphinium carolinianum Walt. [incl. *D. azureum* Michx. (Warnock 1981)]—"Interior state." Reported previously by Parry (1847).
Delphinium tricorne Michx.—"Interior state."
Delphinium virescens Nutt.—Referred here is Rauch's report of *D. exaltatum* Ait., a species coming no nearer than the Ozarks of Missouri and western Ohio; the two are morphologically similar, particularly in their white or pale bluish to purple flowers (Whittemore & Parfitt 1997).
Hepatica nobilis Schreb. var. acuta (Pursh) Steyerm.—"Hills, south side." There is some confusion in the presentation of this and the following taxon. Rauch first cited *H. triloba* Chaix (with its homotypic synonym *Anemone hepatica* L.), giving notes for it including the habitat "Woods." This was then followed by *H. acuta*, a combination not validly published until 1891; and *H. obtusa*, which has never been validly published. It seems likely that he meant to present them as *H. triloba* var. *acuta* Pursh and *H. triloba* var. *obtusa* Pursh, respectively, as was done by Torrey & Gray (1838–43).
Hepatica nobilis Schreb. var. obtusa (Pursh) Steyerm.—"Hills, south side." See note under preceding.
Hydrastis canadensis L.—"Meadows and wet prairies."
Pulsatilla patens (L.) Mill. [*Anemone patens* L.]—"Dry hills."
Ranunculus abortivus L.
Ranunculus acris L.—"Meadows and wet prairies." Earliest record 1904 (Cratty 1929).
Ranunculus aquatilis L.
Ranunculus bulbosus L.—"Fields." Eurasian species, reported from Indianola by Bessey (1871), a report accepted by Arthur (1876) and Fitzpatrick (1899).
Ranunculus fascicularis Muhl. ex Bigel.
*Ranunculus flammula L. var. reptans (L.) E. Mey. [*R. reptans* L.]—As near as southeastern Minnesota.
Ranunculus gmelinii DC. [incl. *R. purshii* Richardson (Fernald 1950)].
*Ranunculus laxicaulis (Torr. & A. Gray) Darby [*R. flammula* L., misappl. (Jones & Fuller 1955)]—"Wet places and swamps." As near as eastern Missouri and western Illinois.
Ranunculus pensylvanicus L. f.
Ranunculus sceleratus L.
*Xanthorhiza simplicissima Marsh. [incl. *X. apiifolia* L'Her. (Fernald 1950)]—"Found south part of state, banks of rivers." No nearer than central Kentucky or southern Ohio.

Rhamnaceae

Ceanothus americanus L.—"Woods."
Rhamnus lanceolata Pursh—"On the Missouri River." Reported previously by Parry (1847). Because of this locality statement, Rauch's report of *R. alnifolia* L'Her. is referred here; that species is confined in Iowa to the northeasternmost counties. The latter was the only species treated by Gray (1848) besides non-native *R. cathartica* L.

Rosaceae

Agrimonia eupatoria L.—"Fields." Eurasian species. However, as circumscribed by Torrey & Gray (1838–43), it also encompassed three species native to Iowa: *A. gryposepala* Wallr., *A. pubescens* Wallr., and *A. striata* Michx. (Kline & Sørensen 2008), and it is more likely that Rauch had one or more of these at hand.
Agrimonia parviflora Ait.—"Woods."
Amelanchier arborea (Michx. f.) Fern. [*A. canadensis* (L.) Medik., misappl. (Fernald 1950)]—"Woods."
Aronia melanocarpa (Michx.) Ell. [*Pyrus arbutifolia* (L.) L.f., misappl. (Jones & Fuller 1955)]—"Woods."
Aruncus dioicus (Walt.) Fern. [*Spiraea aruncus* L., misappl. (Fernald 1950)].
Filipendula rubra (Hill) B. L. Rob. [*Spiraea lobata* Gronov. ex Jacq. (Robinson & Fernald 1908)]—"Prairies."
Crataegus coccinea L.—"Thickets, banks of streams."
Crataegus punctata Jacq.—"Woods."
Fragaria virginiana Duchesne—"Fields, woods."
Geum canadense Jacq.—"Thickets." Referred here is Rauch's report of *G. virginianum* L., an eastern species that comes no nearer than southern Missouri, southern Illinois, and northwestern Indiana, because Torrey & Gray (1838–43) circumscribed *G. virginianum* to include *G. canadense*.
*Geum rivale L.—"N. part of State." As near as northeastern South Dakota, central Minnesota, southwestern Wisconsin, and northern Illinois.
Geum vernum (Raf.) Torr. & A. Gray—"Thickets."
*Gillenia stipulata (Muhl. ex Willd.) Nutt.—"Woods." As near as northeastern Missouri and western Illinois.
Malus ioensis (Wood) Britt.—"Woods." Referred here is Rauch's report of *Pyrus coronaria* L., an eastern species that comes as close as southeastern Wisconsin, northern Illinois, and central Missouri. Specimens of this species were commonly identified as *P. coronaria* prior to its recognition (Lammers 1998).
Physocarpus opulifolius (L.) Maxim. [*Spiraea opulifolia* L.]—"Banks of streams."
Potentilla palustris (L.) Scop. [*Comarum palustre* L.]—"In sphagnous swamps N. part of State."
Potentilla simplex Michx. [*P. canadensis* L., misappl. (Jones & Fuller 1955)]—"Fields."
Prunus americana Marsh.—"Woods."
Prunus pensylvanica L. f. [*Cerasus pennsylvanica* (L. f.) Loisel.]—"Woods."
Prunus persica (L.) Batsch [*Persica vulgaris* Mill.]—"Introduced." Earliest record 1923 (Cratty 1929).
Prunus pumila L. [*Cerasus pumila* (L.) Michx.]—"Shrub sandy soil."
Prunus serotina Ehrh. [*Cerasus serotina* (Ehrh.) Loisel.]—"Woods."
Prunus virginiana L. [*Cerasus virginiana* (L.) Michx.].
Rubus allegheniensis Porter [*R. villosus* Ait., misappl. (Jones & Fuller 1955)]—"Woods."
Rubus flagellaris Willd. [*R. canadensis* L., misappl. (Jones & Fuller 1955)]—"Fields."
Rubus hispidus L.—"Damp woods."
Rubus occidentalis L.—"Fields."
*Rubus odoratus L.—"Woods." No nearer than northern Illinois.
Rubus strigosus Michx.—"Fields."
Spiraea alba DuRoi [*S. salicifolia* L., misappl. (Jones & Fuller 1955)]—"Meadows."
*Spiraea tomentosa L.—"Wet prairies." As near as central Minnesota, southwestern Wisconsin, northern Illinois, and southeastern Missouri.

Rubiaceae
Cephalanthus occidentalis L.
Galium aparine L.—"Wet thickets."
Galium circaezans Michx.—"Woods."
Galium tinctorium L.—"Wet woods."
Mitchella repens L.—"N. part of State."

Rutaceae
Ptelea trifoliata L. Reported previously by Parry (1847).
Zanthoxylum americanum Mill.—"Woods."

Salicaceae
Populus balsamifera L.—"Woods."
Populus deltoides W. Bartr. ex Marsh. [incl. *P. angulata* Ait. (Watson & Coulter 1889, Robinson & Fernald 1908)]—"Banks of rivers."
Populus grandidentata Michx.
Populus tremuloides Michx.
Salix eriocephala Michx. [incl. *S. angustata* Pursh (Argus et al. 2010)]. Eilers and Roosa (1994) used the name *S. rigida* with *S. eriocephala* in synonymy, but the latter in fact has priority (Argus et al. 2010).
Salix exigua Nutt. subsp. interior (Rowlee) Cronq. [*S. longifolia* Muhl., nom. illeg.]—"Banks of streams."
Salix humilis Marsh. [incl. *S. muehlenbergiana* Barratt ex Torr., nom. illeg. (Gray 1848)]—"Dry soils." Rauch's report of *S. tristis* Ait. ("Border of woods") is referred here, where Argus et al. (2010) accorded it varietal rank.
*Salix myricoides Muhl.—"Woods." As near as southwestern Wisconsin and northern Illinois.
Salix nigra Marsh.—"Banks of streams." Rauch's report of *S. purshiana* Spreng., nom. illeg. ("Swamps"), is referred here as well; that name is based upon *S. falcata* Pursh, which Argus et al. (2010) included in this species.

Sapindaceae
*Cardiospermum halicacabum L.—"Banks Missouri." As near as northern Kansas, eastern Missouri, and western Illinois. James (1825) found it to be "Very abundant on the Canadian [River in Oklahoma], two hundred miles above its confluence with the Arkansaw [*sic*]. Undoubtedly a native." Torrey (1828) repeated James' information, but added to it, "On the Missouri." Subsequently, Torrey and Gray (1838–43) construed this as, "On the Missouri and its branches, *Dr. James!*", which may have led to its inclusion by Rauch.

Saxifragaceae
Heuchera americana L.
*Hydrangea arborescens L.—"Banks of streams." As near as northeastern Missouri and western Illinois. Reported from Fayette by Bessey (1871) and Lee County by Arthur (1876).
Parnassia glauca Raf. [*P. palustris* L., misappl. (Jones & Fuller 1955)]—"Bogs, and shores of lakes N. part of state."
Ribes americanum Mill. [incl. *R. floridum* L'Hér. (Fernald 1950)]—"Woods."
Ribes cynosbati L.—"Thickets."
Ribes hirtellum Michx.—"Woods."
Ribes missouriense Nutt. ex Torr. & A. Gray [*R. rotundifolium* Michx., misappl. (Jones & Fuller 1955)]. Reported previously by Parry (1847).
Ribes odoratum Wendl. [*R. aureum* Pursh, misappl. (Fernald 1950)].
Ribes sativum (Rchb.) Syme [*R. rubrum* L., misappl. (Jones & Fuller 1955)]—"N. part of State." Parry (1852) commented on the naturalization of this species around the headwaters of the Chippewa River in northern Wisconsin.

Scrophulariaceae
Chelone glabra L.—"Wet places."
Gratiola virginiana L.
Linaria vulgaris Hill—"Roadsides." Earliest record 1883 (Cratty 1929).
Scrophularia marilandica L. [*S. nodosa* L., misappl. (Robinson & Fernald 1908)]—"Woods."
Verbascum thapsus L.—"Fields, roadsides." Earliest record 1881 (Cratty 1929).
Veronica americana (Raf.) Schwein. ex Benth.—"Brooks."
Veronica officinalis L.—"Dry woods."
Veronicastrum virginicum (L.) Farw. [*Veronica virginica* L.]—"Woods."

Solanaceae
Datura stramonium L. [incl. *D. tatula* L. (Fernald 1950)]—"Waste places." Earliest record 1882 (Cratty 1929).
Lycopersicon esculentum Mill. [*Solanum lycopersicum* L.]—"Introduced."
**Nicotiana rustica* L.—"Introduced … Cultivated by the Indians. Thought to be inferior to the Virginian." Cultigen of tropical American origin.
**Nicotiana tabacum* L.—"Intro. ... Cultivated to a small extent in this State, and thrives well, especially in the south part. Should demand the attention of our farmers." Cultigen of tropical American origin.
Solanum americanum Mill. [*S. nigrum* L., misappl. (Fernald 1950)]—"Way sides, &c." Reported previously by Torrey (1843, 1845).
Solanum dulcamara L.—"Rare. Thickets, &c." Earliest record 1897 (Cratty 1929).
**Solanum tuberosum* L.—"Introduced." Cultigen of South American origin.

Thymeleaceae
Dirca palustris L.—"Banks of streams."

Tiliaceae
Tilia americana L.—"Woods."
Tilia heterophylla Vent. [incl. *T. alba* Michx. (Gray 1848)]—"Banks of Miss."

Ulmaceae
Celtis occidentalis L.—"Woods."
Ulmus americana L.—"Forests."
Ulmus rubra Muhl. [incl. *U. fulva* Michx. (Fernald 1950)]—"Woods, low grounds."

Urticaceae
Urtica dioica L.—"Waste places." Reported previously by Torrey (1843, 1845).

Valerianaceae
Valeriana edulis Nutt. ex Torr. & A. Gray subsp. ciliata (Torr. & A. Gray) F. G. Mey. [*V. ciliata* Torr. & A. Gray]—"Low grounds."
*Valeriana uliginosa (Torr. & A. Gray) Rydb. [incl. *V. sylvatica* Sol. ex Richardson, nom. illeg. (Robinson & Fernald 1908)]—"Swamps. N. part of State." No nearer than central Wisconsin and northeastern Illinois.

Verbenaceae
Verbena hastata L.—"Low grounds."
Verbena urticifolia L.—"Roadside."

Violaceae
Hybanthus concolor (T. F. Forst.) Spreng. [*Solea concolor* (T. F. Forst.) Ging.]—"Woods."
Viola canadensis L.
*Viola conspersa Rchb. [incl. *V. muhlenbergii* Torr. (Robinson & Fernald 1908)]—As near as southern Minnesota and southwestern Wisconsin.
Viola lanceolata L.
Viola macloskeyi Lloyd subsp. pallens (Banks ex DC.) M. S. Baker—Referred here is Rauch's report of *V. rotundifolia* Michx., which

comes no nearer than southwestern Ohio, because the former was originally named as a variety of the latter (*V. rotundifolia* var. *pallens* Banks ex DC.).

Viola pedata L.

Viola pedatifida G. Don [incl. *V. delphinifolia* Nutt. (Watson & Coulter 1889)].

Viola pubescens Ait.

Viola rafinesquii Greene—Rauch's report of *V. arvensis* Murr. is referred here, in light of the nomenclatural history of field-pansies in North America (Clausen et al. 1964).

*Viola rostrata Pursh—No nearer than southeastern Wisconsin and northwestern Indiana.

Viola sagittata Ait.

Viola sororia Willd.—Rauch's report of *V. cucullata* Ait. is referred here. *Viola cucullata* does occur as near as eastern Minnesota and southwestern Wisconsin, but this seems a better disposition in light of the confused nomenclatural history of the common blue violets (McKinney 1992).

Viola striata Ait.

Viola tricolor L.

Viola viarum Pollard—Rauch's report of *V. palmata* L. is referred here, following McKinney (1992), who synonymized the two under the latter name.

Vitaceae

Parthenocissus quinquefolia (L.) Planch. [*Ampelopsis quinquefolia* (L.) Michx.].

Vitis aestivalis Michx.

*Vitis labrusca L.—"Woods ... The Isabella, and Catawba Grapes have been produced in cultivation from this. These thrive well especially on bluffs and hills with southern exposures. Cultivation of them demand the attention of our horticulturalists." No nearer than northwestern Indiana. The cultigens derived from it, which also include the Concord grape, constitute *V. labruscana* L. H. Bailey.

Vitis riparia Michx.

Vitis vinifera L.—"Naturalized. Thrives well." Eurasian cultigen.

Vitis vulpina L. [incl. *V. cordifolia* Michx. (Fernald 1950)].

ANGIOSPERMS: MONOCOTS

Alismataceae

Alisma plantago-aquatica L.—"Ponds, ditches."

Aracaeae

Acorus calamus L.—"Swamps."

Arisaema dracontium (L.) Schott [*Arum dracontium* L.]—"Banks of streams."

Arisaema triphyllum (L.) Schott [*Arum triphyllum* L.]—"Wet woodlands."

*Calla palustris L.—"Wet places. North part of State." As near as eastern Minnesota, southwestern Wisconsin, and northeastern Illinois. Reported from Linn County (Anderson 1948, Beal & Monson 1954) on the basis of specimens collected in 1912 by George Berry (Meyer 1959). Recent authors have discounted the vouchers as erroneous (Eilers & Roosa 1994, Thompson 2000).

Dioscoreaceae

Dioscorea villosa L.—"Thickets." Reported previously by Parry (1847).

Iridaceae

Iris shrevei Small [*I. versicolor* L., misappl. (Beal & Monson 1954)]—"Wet grounds."

Sisyrinchium angustifolium Mill. [incl. *S. anceps* Cav. (Robinson & Fernald 1908, Fernald 1950)]—"Low grounds."

Liliaceae

*Aletris farinosa L.—"Low grounds." As near as southwestern Wisconsin and northern Illinois.

Allium canadense L.—"Woods, prairies."

**Allium cepa* L.—"Introduced." Eurasian cultigen

Allium cernuum Roth—"Hill sides."

Allium tricoccum Sol.—"Damp woods."

Allium vineale L.—"Meadows."

Asparagus officinalis L.—"Cultivated." Earliest record 1892 (Cratty 1929).

Camassia scilloides (Raf.) Cory [incl. *Phalangium esculentum* (Ker-Gawl.) Nutt. (Gould 1942)]—"Wet prairies." Reported previously by Parry (1847).

*Chamaelirium luteum (L.) A. Gray [incl. *Helonias dioica* (Walt.) Pursh (Gray 1848)]—"Low grounds." No nearer than southern Illinois and southern Indiana.

*Clintonia borealis (Ait.) Raf. [*Convallaria borealis* (Ait.) Poir.]—"Woods." As near as central Minnesota and southwestern Wisconsin.

Erythronium albidum Nutt.—"Wet prairies." Reported previously by Parry (1847).

Erythronium americanum Ker-Gawl.—"Woods."

Lilium michiganense Farw. [*L. canadense* L., misappl., and *L. superbum* L., misappl. (Jones & Fuller 1955)].

Lilium philadelphicum L.

Maianthemum canadense Desf. [*Convallaria bifolia* L., misappl. (Watson & Coulter 1889)]—"Woods."

*Maianthemum trifolia (L.) Sloboda [*Convallaria trifolia* L.]—"Wet prairies." As near as southeastern Minnesota and southern Wisconsin.

*Medeola virginiana L.—As near as northern Illinois and northern Missouri.

Melanthium virginicum L.—"Woods." Referred here is Rauch's report of *M. hybridum* Walt., a species of the Appalachians occurring no nearer than western Pennsylvania and central Tennessee.

Ornithogalum umbellatum L.—"Introduced. Abundant." Not mentioned by Cratty (1929).

Polygonatum biflorum (Walt.) Ell. [*P. multiflorum* (L.) All., misappl. (Gray 1856)]—"Woods."

Smilacina racemosa (L.) Desf. [*Convallaria racemosa* L.]—Rauch's notes on medicinal use of this seem to be based on his personal experience rather than the literature, and may relate to his medical school dissertation (Kelly & Burrage 1920, Beatty 1991).

Smilacina stellata (L.) Desf. [*Convallaria stellata* L.]—"Banks of streams."

Smilax herbacea L.—"Low grounds."

Smilax hispida Muhl. ex Torr. [*S. rotundifolia* L., misappl. (Jones & Fuller 1955)]—"Thickets."

Trillium cernuum L.—The name used by Rauch, *T. pendulum* Willd., is properly a synonym of *T. erectum* L., an eastern species occurring no nearer than northern Illinois; however, "later usage of the name may possibly refer in part to *T. cernuum*" (Gleason 1906).

*Trillium grandiflorum (Michx.) Salisb.—"Woods." As near as southern Minnesota, southwestern Wisconsin, and western Illinois. Isaiah Reid (1836–1911), who graduated from Yellow Springs College in nearby Kossuth in 1861 (Kerwin 2006), told Bessey (1871) that he had collected this at Burlington.

Trillium nivale Riddell—"Dr. James' farm, Des Moines county." This was located along Rock Spring, four miles southwest of Burlington, in southern Union Township (Pammel 1907–08, Benson 1968).

Trillium recurvatum Beck—"Shady woods."

*Trillium sessile L.—"Woods." As near as northeastern Missouri and

western Illinois. Parry (1852) reported this from Davenport, while Isaiah Reid told Bessey (1871) that he had collected it at Burlington.

Uvularia grandiflora Sm.—"Woods." Rauch's report of *U. perfoliata* L. ("Woods, bluffs, near Burlington") is also referred here (Fitzpatrick 1906, Jones & Fuller 1955). This is a southeastern species of similar but smaller appearance that comes no nearer than southern Indiana, western Kentucky, and northern Arkansas.

Veratrum woodii J. W. Robbins ex A. Wood—"Swamps." Rauch's report of *V. viride* Ait., a northern species coming no nearer than eastern Ohio or central Montana, is referred here.

Zigadenus glaucus (Nutt.) Nutt.—"Sandy places."

Orchidaceae

Cypripedium calceolus L. var. parviflorum (Salisb.) Fern. [*C. parviflorum* Salisb.]—"Prairies."

Cypripedium candidum Muhl. ex Willd.—"Prairies." Reported previously by Parry (1847).

Goodyera pubescens (Willd.) R. Br.—"Woods."

*Platanthera orbiculata (Pursh) Lindl. [*Orchis orbiculata* Pursh]—"Woods." As near as southwestern Wisconsin and northern Illinois.

Poaceae

Zea mays L.

Zizania aquatica L.—"Swamps, ponds, &c. N. part of State."

Typhaceae

Typha latifolia L.—"Muddy pools and ditches."

CONCLUSIONS

The most obvious question prompted by the discovery of Rauch's (1851a) report is, "How does it compare to what we know about the Iowa flora today?" In answering this question, native and non-native species will be considered separately, in order to have a consistent standard for comparison. The number of species found in Iowa today is far greater than in 1850, due to the naturalization of plants from other regions (Cratty 1929, Eilers & Roosa 1994, Lewis 1998, Norris et al. 2001).

Native plants.—Of the 135 families with species native to Iowa (Eilers & Roosa 1994), 83 (61%) were represented in Rauch's report. The most glaring absences were Cyperaceae, with 160 native species, followed by Potamogetonaceae (18 spp.) and Juncaceae (16 spp.). When one adds to this the fact that the report had but one of the 150 native species of Poaceae, no Amaranthaceae, and no native Chenopodiaceae, one begins to suspect that Rauch felt some aversion for apetalous herbs.

Of Iowa's 1516 native species (Eilers & Roosa 1994), 348 (23%) were listed by Rauch. Among these were some of very rare occurrence or very limited distribution within the state, e.g., *Abies balsamea, Asimina triloba, Drosera rotundifolia, Filipendula rubra, Ranunculus gmelinii,* and *Sassafras albidum*. Conversely, the three-quarters of the native flora not listed did include several exceedingly common and conspicuous species, the sorts of things any neophyte botanist in the Midwest learns in his first season, e.g., *Aster novae-angliae* L., *Calystegia sepium* (L.) R. Br., *Phlox divaricata* L., *Rosa carolina* L., *Rudbeckia hirta* L., *Sagittaria latifolia* Willd., *Solidago canadensis* L., and *Tradescantia ohiensis* Raf. The absence of such common eye-catching plants is puzzling.

Of particular interest are the species Rauch reported that were not listed by Eilers and Roosa (1994), i.e., the 86 denoted in the list above by an asterisk. The lack of voucher specimens means that these species cannot be stated with certainty to have once been members of the Iowa flora. However, their presence in the report is suggestive of possibilities to be explored, through further collecting in the field and searches of out-of-state or neglected in-state herbaria. For some of these supernumeraries (e.g., *Dentaria diphylla, Lindera benzoin*), there are additional undocumented literature reports, which may increase the credibility afforded Rauch's report.

Particularly credible are the 38 species whose current distributional limits lie immediately adjacent to Iowa, in many cases, in border counties. Some of these very well may have grown in Iowa prior to settlement, but been extirpated subsequently. Populations at the periphery of a species' distribution may be particularly prone to extirpation in the wake of habitat loss due to agriculturalization.

The ranges of 24 of these extend into southeastern Minnesota and/or southwestern Wisconsin from the north and east. Thus it is plausible that some or all might once have been native but rare in northeastern Iowa, following the pattern of *Abies balsamea, Cornus canadensis,* and *Linnaea borealis* L. (Pusateri et al. 1993). These are *Aletris farinosa, Calla palustris, Clintonia borealis, Comptonia peregrina, Coptis trifolia, Dentaria diphylla, Gaultheria procumbens, Geum rivale, Maianthemum trifolia, Panax trifolius, Picea mariana, Pinus resinosa, Platanthera orbiculata, Ranunculus flammula, Salix myricoides, Spiraea tomentosa, Toxicodendron vernix, Trillium grandiflorum, Tsuga canadensis, Vaccinium corymbosum, V. macrocarpon, V. oxycoccos, Viburnum acerifolium* (in fact, recently collected in the state), and *Viola conspersa.*

The other 14 have ranges that extend into northeastern Missouri and/or western Illinois from the south and east. Thus it is plausible that some or all once may have been native but rare in southeastern Iowa, following the pattern of *Diospyros virginiana* L., *Fraxinus quadrangulata*, and *Sassafras albidum* (Davidson 1959). These are *Alnus serrulata*, *Carya glabra* (recently discovered specimens may document its existence in the state), *Cunila origanoides*, *Erigenia bulbosa*, *Eupatorium fistulosum*, *Gillenia stipulata*, *Hydrangea arborescens*, *Hypericum adpressum*, *Lindera benzoin*, *Medeola virginiana*, *Ranunculus laxicaulis*, *Sabatia angularis*, *Trifolium stoloniferum*, and *Trillium sessile*.

Another 36 supernumeraries occur in adjoining states, but not particularly closely. Although some (e.g., *Gaultheria hispidula*, *Oxalis montana*, *Polygala paucifolia*) do not tax credibility overmuch, others such as *Taxodium distichum* and *Oenothera macrocarpa* seem very unlikely to have been native to Iowa due to their habitat requirements. Such reports likely are due to misidentification of specimens or (see above) the misinterpretation of distributions reported in the literature (e.g., *Artemisia santonicum*, *Gentiana acuta*).

Seven supernumeraries are especially puzzling, as they are not native to adjacent states, or in some cases within hundreds of miles of Iowa: *Aristolochia macrophylla*, *Euphorbia ipecacuanhae*, *Ipomoea jalapa*, *Pinus palustris*, *Scutellaria integrifolia*, *Vitis labrusca*, and *Xanthorhiza simplicissima*. Most are so distinctive in appearance that it is difficult to imagine what native plant might have been mistaken for them. Given that all but one is of some economic value, one wonders if they were in fact cultivated rather than naturally occurring, without that fact being noted.

Non-native plants.—Of the 441 species treated as non-native by Eilers and Roosa (1994), Rauch listed 66 (15%). Does this mean that the remaining 355 had yet to be introduced to the state? Clearly, this is true for some (cf., Pohl 1959; Pohl & Sylvester 1962; Lammers 1997; Cusick 2002). But in light of the many common native species overlooked (see above), it does not seem wise to assume that the absence of a non-native species means it had not been introduced yet. Consequently, a detailed temporal comparison (cf., Myers & Henry 1979) is not practicable. We can say, however, that these 66 species were apparently introduced to Iowa within the first 18 years after the territory opened to settlement. In every case, this is considerably earlier than the year of first documentation reported by Cratty (1929). Many were unintentional introductions, others deliberate (cf. Mack 1991). Many have gone on to become widespread, even ubiquitous in the state, e.g., *Brassica nigra*, *Polygonum persicaria*, *Taraxacum officinale*. Others, despite their early introduction, are still quite scarce, e.g., *Chelidonium majus*, *Lithospermum arvense*, *Senecio vulgaris*.

Fifteen non-native species were listed by Rauch but not by Eilers and Roosa (1994). Three (*Origanum vulgare*, *Ranunculus bulbosus*, *Rumex sanguineus*) are sporadically naturalized in much of North America and their presence in Iowa would not be surprising. The remaining 12 were explicitly noted as cultivated: *Allium cepa*, *Cucurbita pepo*, *Euphorbia lathyris*, *Ipomoea batatas*, *Lonicera flava*, *Melissa officinalis*, *Nicotiana rustica*, *N. tabacum*, *Ricinus communis*, *Solanum tuberosum*, *Symphytum officinale*, and *Vitis vinifera*. Plants of this sort were expressly omitted by Eilers and Roosa. It is worth noting that while some cultigens (e.g., *Daucus carota*, *Mentha spicata*, *Pastinaca sativa*) had already established themselves outside gardens at this very early date, others that are naturalized now were only known to Rauch from cultivation (e.g., *Asparagus officinalis*, *Cannabis sativa*, *Maclura pomifera*).

SUMMARY

This forgotten first checklist of the Iowa flora was an amazing achievement. In a single field season of four or five months, a 22-year-old amateur newly arrived in the state documented 501 species. This represented almost one-quarter of the native species known today and 15% of the non-native, and included 87 species not currently accepted as occurring in the state. He did this at a time when there was no mechanical means of land transportation, in a frontier region lacking scholarly resources, and while establishing his first medical practice.

Despite the lack of documentary specimens, the report paints for us a picture of a time when the Iowa landscape was relatively unmolested; a time when a number of northern, eastern, and southern species may still have had peripheral populations within the state; a time before many non-native species had invaded the

state and supplanted the indigenes. It also shows us what was possible for dedicated workers to achieve in a time when floristic study was avocational, a hobby for educated men rather than the livelihood of professional botanists. Further, it is a cautionary tale, reminding us that documentary herbaria held by individuals are far more vulnerable and ephemeral than those in the custody of institutions.

Rauch's report also provides interesting insights into the medical profession of the mid-Nineteenth Century. Mainstream practitioners of that era often are characterized as practicing few therapies beyond venesection and the cathartic purging of the gastrointestinal tract, and as employing a limited pharmacopeia built around toxic mineral substances such as mercurous chloride, mercuric chloride, and potassium antimonyl tartrate (Watson 1894; Fairchild 1927; Berman 1957, 1958; Lawrence 2003). Great animosity was said to exist between them and the Thompsonian, Reformed Botanic, and Eclectic physicians, who eschewed such "heroic" practices and instead embraced a diverse array of drugs derived from plants (Beach 1833; Stuckey 1978).

The attention afforded medicinal plants by the Iowa State Medical and Chirurgical Society in its first years of existence, however, suggests that this animosity has been exaggerated. Medical societies such as this one were explicitly founded to counter the influence of those viewed by mainstream physicians as quacks and charlatans. But the review of Rauch's report by Sanford (1851) makes clear that the use of medicinal plants per se was not grounds for denigration. Rather, it was the uneducated peddlers of "Indian cures," "snake oil," and other nostrums who were condemned.

> ... the developement of the medical resources of the Vegetable Kingdom, must depend upon the true and legitimate physicians of the country. Abominable tricksters have deceived the people in proclaiming themselves "Eclectics," "Botanics," &c, &c, professing to draw their remedies from the Vegetable Kingdom, while we dare assert, and defy any of them to the trial, that not one of these empirics in Iowa, knows any thing about the first principles of Medical Botany. They are an ignorant race who never have made, and never will make any valuable contributions to Medical science, and the sooner the intelligent people of the State encourage a test of this kind the better.

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A PRELIMINARY REPORT OF MESCALINE CONCENTRATIONS IN SMALL REGROWTH CROWNS VS. MATURE CROWNS OF *LOPHOPHORA WILLIAMSII* (CACTACEAE): CULTURAL, ECONOMIC, AND CONSERVATION IMPLICATIONS

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ABSTRACT

A phytochemical analytical study was conducted to address the question of whether the mescaline concentration in *Lophophora williamsii* (peyote) is dependent on the maturity and/or size of the plant. Samples of crown tissue (4 g each) biopsied from mature peyote cacti and whole small regrowth crowns (2–4 g each) were collected from the same population in the Tamaulipan Thornscrub ecoregion of South Texas. For each of the two groups (mature and small regrowth), the individual tissue samples were pooled, desiccated, and ground to powder. The alkaloids were extracted with methanol at 25°C, followed by evaporation of the methanol to dryness, then acid-base cleanup with water and dichloromethane. The mescaline concentration in each of the extracts was then determined by HPLC. Quantitative analyses provided evidence that the small crowns that develop in response to harvesting contain a lower mescaline concentration—about half as much—compared to that of crowns of mature unharvested plants in the same population. The deficiency in the mescaline concentration of these regrowth buttons (new crowns) exacerbates the problem posed by the small size of the buttons; that is, it further increases the number of buttons that must be consumed to obtain an efficacious dose for ceremonial use by members of the Native American Church (NAC). That means that either the NAC members must consume less than the traditional amount of peyote, or there will be increased demand for peyote. Any increase in demand, reflected in the price, will engender more intensive harvesting, which will inevitably have adverse effects on both the supply of sacrament for the NAC and the conservation status of *L. williamsii* wherever the harvesters have access to peyote populations.

KEY WORDS: peyote conservation status, Native American Church, peyote overharvesting, dosage of mescaline, dosage of peyote, ethnopharmacology

RESUMEN

Se hizo un estudio fitoquímico analítico para determinar si la concentración de mescalina de *Lophophora williamsii* (peyote) depende de la madurez y/o el tamaño de la planta. Se recogieron muestras de tejido de la corona (4 g cada una) tomadas por biopsia en individuos maduros de peyote y muestras de coronas pequeñas enteras recrecidas (2–4 g cada una) de la misma población en la ecorregión del matorral espinoso tamaulipeco en el sur de Texas. Para cada uno de los dos grupos (maduros y pequeños recrecidos), las muestras individuales de tejido fueron combinados, secados, y molidos hasta polvo. Los alcaloides fueron extraídos con metanol a 25°C, seguido de evaporación del metanol hasta sequedad, y después una limpieza ácida- alcalina con agua y diclorometano. La concentración de mescalina en cada uno de los extractos fue determinada entonces por HPLC. Los análisis cuantitativos mostraron que las coronas pequeñas que se desarrollan como consecuencia del la cosecha contienen una concentración de mescalina más baja—aproximadamente la mitad—en comparación a la de coronas de plantas maduras no cosechadas en la misma población. La deficiencia en la concentración mescalínica de estas coronas recrecidas exacerba el problema causado por el tamaño pequeño de las mismas; es decir, aumenta aún más el número de "botones" (coronas) que tienen de consumirse para obtener una dosis eficaz para el uso ceremonial por miembros de la Native American Church (NAC). Eso significa que o los miembros de la NAC tienen que consumir menos cantidad tradicional de peyote, o habrá un aumento en la demanda de peyote. Cualquier aumento en la demanda, reflejado en el precio, engendrará recolección más intensiva, la cual inevitablemente tendrá efectos adversos, tanto en la provisión del sacramento para la NAC como en el estado de conservación de *L. williamsii* dondequiera que los peyoteros tengan acceso a las poblaciones de peyote.

INTRODUCTION

Lophophora williamsii (Lem. ex Salm-Dyck) J.M. Coult. (Cactaceae)—commonly known as peyote—is a small, spineless, globular cactus of northeastern Mexico and adjacent Texas (Fig. 1). It is of cultural and economic importance for its use as the religious sacrament of the Native American Church (NAC). The harvested crowns of peyote plants, either fresh or dried, are ingested orally as the sacrament in NAC ceremonies. Although *L. williamsii* contains over 50 alkaloidal substances (Anderson 1996), such spiritual use of the plant is evidently based largely on the psychoactive properties of an adequate dosage of its principal alkaloid, mescaline (Huxley 1955). The supply of peyote to registered NAC members is available through regulated channels involving the Texas Department of Public Safety and a very small number of licensed peyote distributors—currently there are three—who purchase their supply from agents (peyoteros) who harvest peyote from wild populations in South Texas. The peyoteros are paid by the piece, according to the number of buttons harvested and delivered to the place of business of a peyote distributor.

Over the past few decades peyote has become scarce in many parts of its historical geographic range. The largest part of the reduction in peyote population size is clearly habitat destruction associated with urban sprawl and adverse agricultural practices, notably root-plowing, which uproots and kills peyote along with the native brush, effectively exterminating the peyote along with the associated plants of its natural habitat, so that the damage to peyote in a root-plowed tract is absolute and permanent. Another major cause of the decline of peyote is overharvesting of the plant for ceremonial use by the NAC. Overharvesting of peyote has several different adverse effects on the wild populations:

(1) It reduces the harvestable population size, and selectively removes the largest crowns first, as these are most valued in the peyote market.

(2) That reduces the quantitative reproductive output of the population, as a direct consequence of the removal of the largest crowns that produce most of the seed in an unharvested population. In terms of population genetics, while such selective harvesting of the largest plants may not have a marked short-term effect on population size (assuming good harvesting practices, benign weather, and consequently a low mortality rate in harvested individuals), it has the immediate effect of reducing the effective population size.

(3) Concomitantly, there is a qualitative genetic loss in the selective loss of seed production from the oldest individuals, which are ipso facto best adapted to local conditions. That loss may be temporary, if the harvested plants survive to produce regrowth buttons that are allowed to mature after a few years, or it may be permanent, if mortality occurs in the old plants due to repeated harvesting of regrowth buttons (Terry et al. 2012).

(4) The phenomenon of post-harvest regrowth of new crowns arising from areoles of the subterranean stem (Terry & Mauseth 2006) temporarily increases the number of crowns in the population, but severely decreases both the average size and the total combined weights of crowns in the population (Terry et al. 2011).

(5) The decreased size of peyote buttons available to the NAC means that an individual in an NAC peyote ceremony must consume more buttons to equal the weight of the smaller number of buttons that would be consumed if mature crowns were available. This leads to a vicious circle of more frequent harvesting to supply the demand for greater numbers of buttons, which leads to the early harvesting of yet smaller buttons—but now fewer, as the overharvested plants exhibit signs of decreased energy reserves for the production of more new crowns following repeated harvesting at two-year intervals (Terry et al. 2012).

(6) Looking at the quality of peyote for ceremonial use in purely pharmacological terms, there would appear to be yet another disadvantage to regrowth buttons for ceremonial use, apart from their small size, and that is the possibility that the dry-weight concentration of mescaline in the small regrowth buttons is substantially lower than in mature peyote crowns, which now constitute a minor percentage of the total offering in the regulated peyote market.

Accordingly, the purpose of the current study was to address the hypothesis that small regrowth peyote



Fig. 1. A mature eight-ribbed peyote cactus (diameter ca. 5 cm) in habitat.

crowns have lower concentrations of mescaline (on a dry-weight basis) than control mature crowns from plants in the same population.

MATERIALS AND METHODS

Fourteen small regrowth peyote crowns weighing 2–4 grams each (fresh weight) were collected from 14 individual plants in a South Texas population in March 2012. (These samples are hereafter referred to as the "Small Regrowth group".) Biopsy samples of crown tissue (ca. 4 g fresh weight from each individual) were field-collected from 10 mature (eight-ribbed) individual peyote plants in the same population. (These samples are hereafter referred to as the "Mature group".) The cactus tissue from each group was cut into small slices, which were set to dry for a week on a drying rack at room temperature. Once desiccated, the tissue of each group was ground to a fine powder with a mortar and pestle. At that point the individual plant samples in each group were pooled and mixed to constitute a single homogeneous sample to represent each group. A sample of 2.0 g of the ground cactus tissue from each group was then placed in a 200-mL beaker to which 100 mL of HPLC-grade methanol was added. The beaker for each sample was sealed with Parafilm® to prevent evaporation of the methanol, and the beakers were kept at room temperature with daily swirling for a week to effect alkaloid extraction. The methanol extract was evaporated to dryness in the hood at room temperature, and the residue of each extract was dissolved in 200 mL HPLC-grade water. The pH was lowered to approximately 3 with concentrated HCl. The acidified aqueous extract was poured into a 500-ml separatory funnel, to which 50 mL of dichloromethane was added. The separatory funnel was shaken to mix the aqueous and dichloromethane phases thoroughly, and

the aqueous and dichloromethane layers were then allowed to separate overnight. The rationale was that protonated phenethylamines such as mescaline and protonated tetrahydroisoquinolines such as pellotine remain in the acidified aqueous layer, while less polar substances dissolve preferentially in the dichloromethane layer. The latter, containing fats and other nonpolar compounds, was drained out of the separatory funnel and set aside. Two additional defatting extractions of the remaining acidified aqueous phase in the separatory funnel were done, each with 50 mL of dichloromethane, and in each case the aqueous and organic layers were allowed to separate, whereupon the dichloromethane phase was drained from the separatory funnel and discarded.

After the third defatting extraction of the acidified aqueous phase, the aqueous phase was drained from the separatory funnel into a beaker, and its pH was raised from 3 to 12 with sodium hydroxide (5 M), in order to deprotonate close to 100% of the mescaline (pK_a = 9.5). The alkalinized aqueous extract was then poured into a separatory funnel, and 50 mL of dichloromethane was added. The rationale was that alkalinizing the aqueous phased in this classic acid-base cleanup procedure was that the deprotonated alkaloids would now be more soluble in the nonpolar dichloromethane than in water. The organic and aqueous phases were mixed well and left to separate. The dichloromethane layer was drained into a 200-mL beaker and saved. Another 50 mL of dichloromethane was then added to the remaining alkaline aqueous phase in the separatory funnel. Upon separation of the organic and aqueous phases, the organic phase was added to the first dichloromethane extract, and the combined extracts were left in a hood at room temperature to evaporate to dryness. The residue, containing the mescaline and related alkaloids, was then redissolved in 10.0 mL of methanol and stored in the freezer in a sealed vial. Samples of the two extracts (Small Regrowth and Mature) were run on an Agilent 1260 Infinity HPLC with a diode-array detector (G4212B) set at 205 nm, using 70% methanol (HPLC grade) as the mobile phase, and a Phenomenex Gemini 5µ C18 column as the stationary phase. Samples of 1.0 µL were injected with a flow rate of 1.0 mL/min and run for 30 minutes. Each of the two samples of alkaloid extract, after appropriate dilution to obtain on-scale HPLC peaks, was run three times, and the values of area under the curve (AUC) of the three runs per sample were averaged. Appropriate dilutions were made of mescaline standard and run on the HPLC three times under the same conditions described above, to create a standard curve. The mean AUC value for each sample of alkaloid extract was then interpolated on the standard curve to yield the corresponding weight (in µg) of mescaline in the HPLC sample of alkaloid extract. From the latter value (one such concentration value per sample group), we calculated the original concentration of mescaline in the homogenized desiccated tissue sample from the Small Regrowth group and in that of the Mature group.

Confirmation of the identity of mescaline in these samples was achieved with GC/MS. A sample methanol extract of *L. williamsii* from this study was evaporated to dryness under an N_2 stream at room temperature, and the residue dissolved in dichloromethane for analysis. The instrumentation was an Agilent 6890 GC equipped with a DB-5ms (0.25 mm I.D. × 30 m) column, splitless injection (250°), and an Agilent 5972 MSD (transfer line at 275°), operated in full scan mode. Helium was used as the carrier, and the oven program was 70° (with a 1-min hold), then 20°/min to 250°, with a final hold. The mescaline peak had an identical retention time to that of an authentic reference sample, and the mass spectrum matched a spectrum in the NIST database (Stein et al. 2005) with 93.5% probability of best match.

RESULTS AND DISCUSSION

Group mescaline concentrations for the Small Regrowth and Mature groups sampled are presented in Table 1. The group values reported are physical averages resulting from the within-group pooling and homogenization of tissue samples of the individual plants sampled and are not statistical means. (A forthcoming manuscript from our lab will report mescaline concentration data on a substantially larger number of individuals in different life stages and size ranges, with statistical analysis of individual values of mescaline concentration in crown tissue.) Mescaline concentrations were 3.80 g/100g tissue in the Mature group and 2.01 g/100 g tissue in the Small Regrowth group, based on tissue samples ≥ 2 g fresh weight from 10 individuals in the Mature group and 14 individuals in the Small Regrowth group. The difference between these levels amounted to a 47% reduction in mescaline concentration in the Small Regrowth group compared to the Mature group. A gas chromatogram

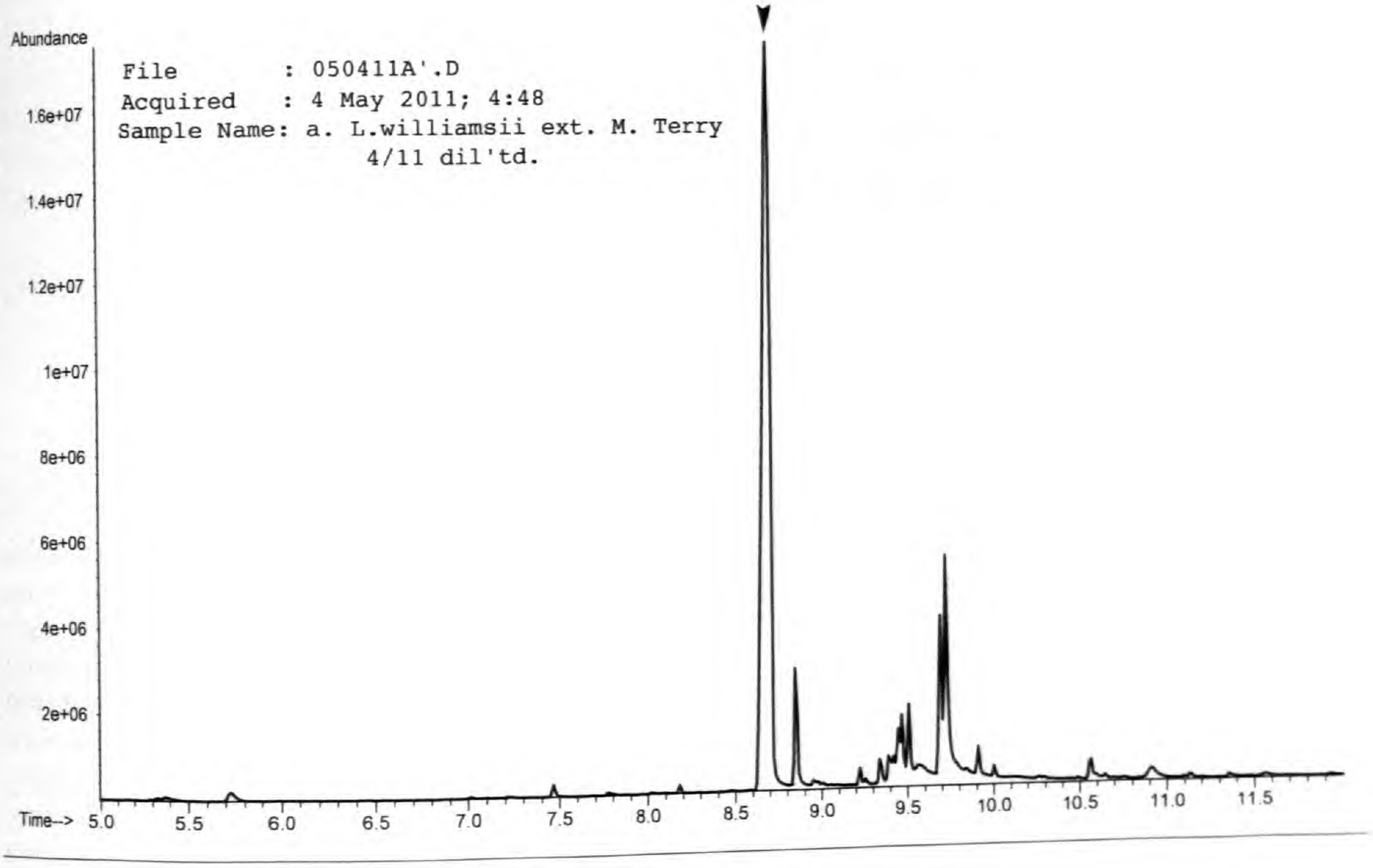


Fig. 2. Gas chromatogram of peyote extract showing prominent mescaline peak.

Table 1. Mean mescaline concentration as percentage of mescaline as a constituent of peyote crown tissue (dry-weight basis) in "Mature" peyote crowns and "Small Regrowth" crowns sampled in situ from the same population in South Texas.

Crown Type	Group Mescaline Concentration (as % of dry tissue weight)
Mature	3.80
Small Regrowth	2.01

of peyote extract and a mass spectrum of the most prominent GC peak from peyote extract are presented in Figs. 2 and 3, respectively.

These data support the hypothesis that mescaline concentrations are reduced in small regrowth crowns of peyote in comparison to the concentrations in mature crowns from plants not previously harvested. This confirms the validity of the widespread opinion among NAC members that small regrowth buttons are "weaker" than larger, mature peyote crowns (T. Herrera, pers. obs.). It also adds another dimension to the damage being done by the too frequent harvesting of peyote in South Texas. Mature crowns have been largely replaced by small regrowth crowns in the peyote market. In order to obtain an effective ceremonial dose of the sacrament, an NAC participant in a peyote meeting must consume a substantially greater number of small buttons than would be the case with mature buttons. The finding in the current study that small regrowth buttons are indeed lower in mescaline concentration than mature buttons, favors consumption of still larger numbers of buttons by each participant in an NAC meeting in order to get "enough" peyote to attain the appropriate spiritual state. Such compensatory increased consumption of peyote attributable to reduced mescaline **concentration**—in addition to the increased consumption required to compensate for the small **size** of the regrowth buttons—can only exacerbate the vicious circle of increased harvesting leading to increased consumption leading to increased harvesting. At the population level in South Texas, this vicious circle has been seen (MT & KT, pers. obs.) to progress downward to the bottom of the extinction vortex for *L. williamsii*.

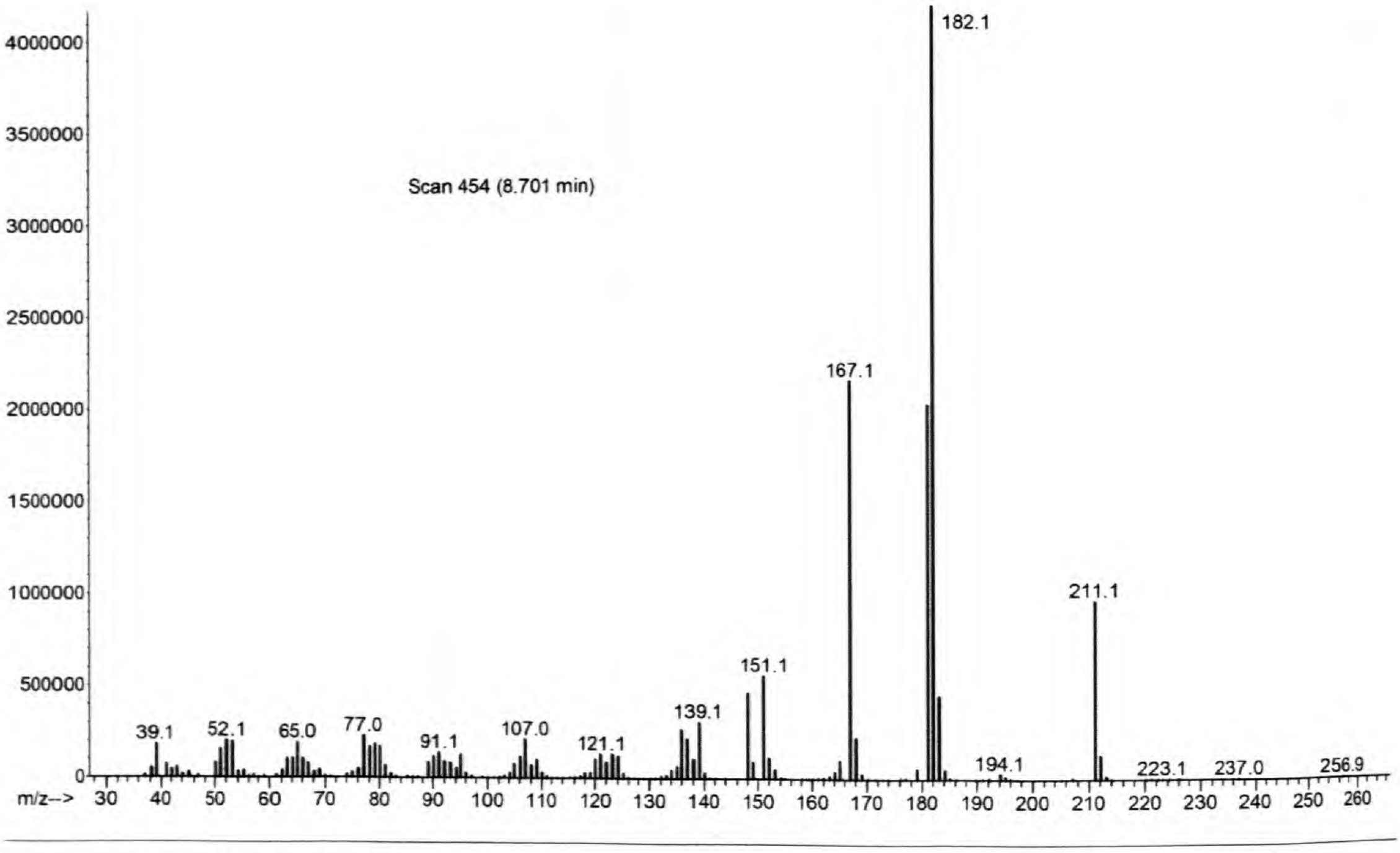


Fig. 3. Mass spectrum of the prominent GC peak in Fig. 2. This spectrum matches that of mescaline with P = 93.5%.

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POTENTIAL DISTRIBUTION OF THREE NATIVE AND ONE INTRODUCED GRASS SPECIES IN SEMIARID HIGHLANDS OF MEXICO USING GIS TECHNIQUES

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ABSTRACT

In the arid and semiarid region of Mexico, data on three native grasses growing in diverse ecological environments—*Muhlenbergia peruviana* (P. Beauv.) Steud., in temperate forests; *Bouteloua gracilis* (Kunth) Lag. ex Griffiths, in grasslands; *Muhlenbergia porteri* Scribn. ex Beal, in xeric regions; and one introduced nonnative species, *Melinis repens* (Willd.) Zizka (Zizka rose Natal grass)—were used in our essay analyzing their potential distribution, based on climatic factors. We took presence-only data applied to the Bioclim algorithm included in the Diva-GIS program. Using database bioclimatic WorldClim-Global Climate Data allowed us to make predictions of the distribution, and to determine the climatic characteristics that each species needs to grow. It generated a potential distribution of the four species under study, concluding that this method can be applied to other grass species from this geographic area in order to improve: a) knowledge of the actual distribution of species in their natural environment, b) knowledge related to biodiversity, and c) to create an indicator to support decisions related to conservation and management of grasses in Mexico. We concluded that possibly climatic requirements prevent the expansion of the introduced species (Zizka rose, Natal grass).

Key Words: semiarid region, Diva-GIS, Mexico, predicted distribution, Poaceae

RESUMEN

En la región árida y semiárida de México se realizó un ensayo con información de tres gramíneas que crecen en ambientes ecológicos diversos—*Muhlenbergia peruviana* (P. Beauv.) Steud., en bosque templado; *Bouteloua gracilis* (Kunth) Lag. ex Griffiths, en pastizal; *Muhlenbergia porteri* Scribn. ex Beal, en matorral xerófilo; y una especie introducida de África, *Melinis repens* (Wild.) Zizka (pasto rosado)—para analizar su distribución potencial en base a factores climáticos. Usamos datos de solo presencia aplicados al algoritmo Bioclim incluido en el programa Diva-GIS. Utilizando la base de datos bioclimáticos WorldClim–Global Climate Data, nos permitió hacer predicciones de la distribución y conocer las características climáticas que cada especie requiere para sobrevivir. Se generó un área potencial de distribución de las 4 especies en estudio, concluyéndose que este método puede ser aplicado a otras especies de esta área geográfica con el fin de mejorar a) el conocimiento de la distribución actual de las especies en su ámbito natural, b) conocer mejor la biodiversidad, y c) crear un indicador para la toma de decisiones en la conservación y manejo de las gramíneas en México. Concluimos que posiblemente los requerimientos climáticos de la especie introducida (pasto rosado) previenen su expansión.

INTRODUCTION

The distribution of the terrestrial surface of grasses, unlike any other living plants, follows a specific order since individuals are not randomly distributed on the ground but rather follow certain patterns. Since the majority of plants are immobile, they must satisfy their requirements "in situ": they must obtain the raw material for their sustenance from the surrounding environment which should also have adequate physical-chemical conditions. Different species require diverse conditions: some plants will be able to live within a specific area while others require a different one (Ederra 1997).

Floristic studies of the north central region of the country (Fig. 1) found nearly 500 species of grasses of the Poaceae family (Herrera 2001; Herrera & Peterson 2007; Herrera & Cortés 2009, 2010; Herrera et al. 2010; Cortés & Herrera 2011; Herrera et al., in prep); their distribution and diversity are due to the availability of their raw-material requirements and the suitable physical-chemical conditions of the environment.

Since the geographical distribution of grass species is determined by their requirements, eco-geographical modeling studies, understood as "... the process of merging information about taxonomy, genetic diversity,

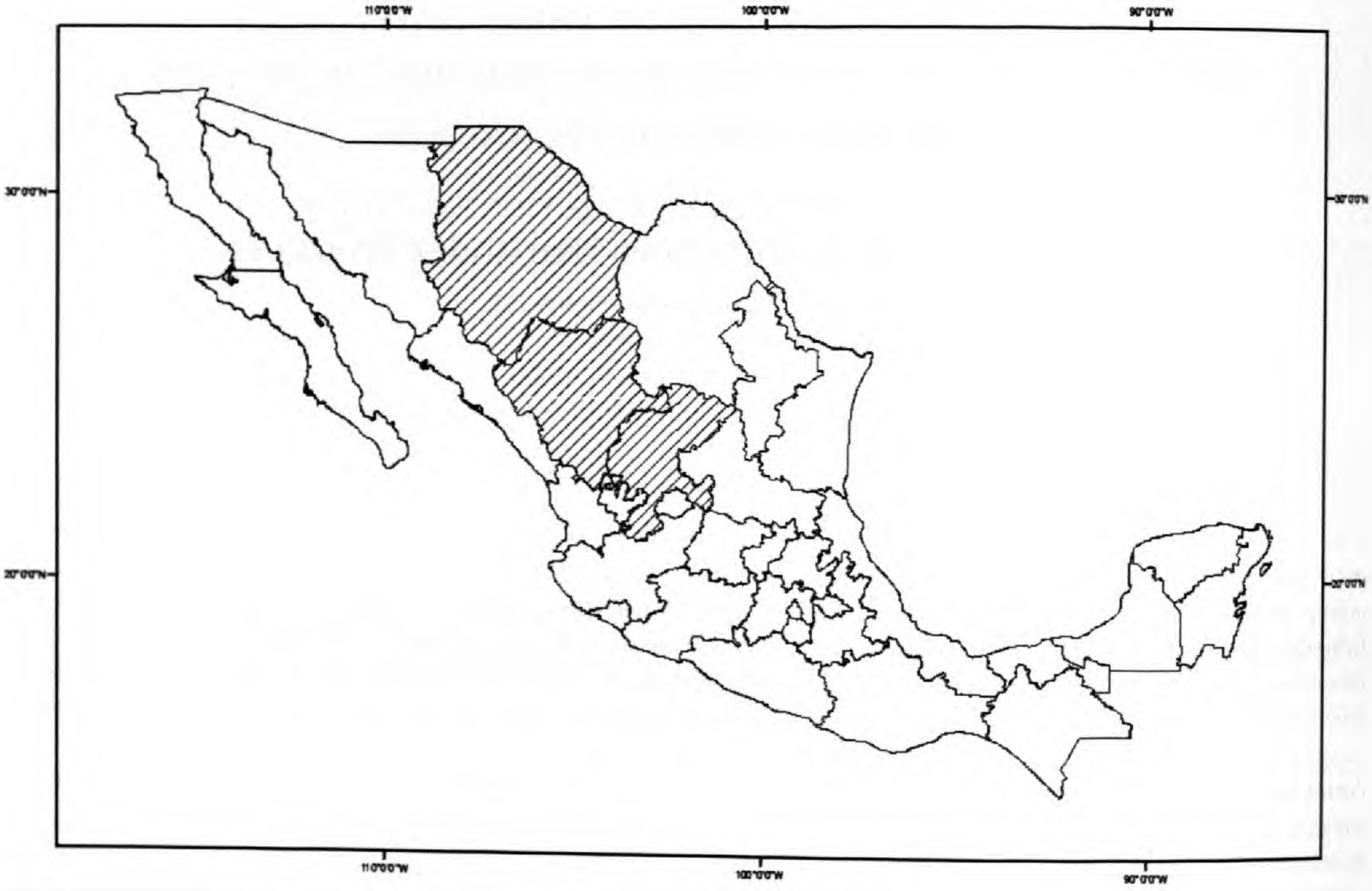


FIG. 1. Geographical location of the study area.

geographical distribution, ecological and ethnobotanical adaptation of a group of plants with geography, ecology, climate and human settlements... " (Guarino et al. 2002), can be used to analyze this distribution. Ecological and geographical information on species is fundamental for conservation, planning, and prediction (Ferrier 2002; Funk & Richardson 2002; Rushton et al. 2004), as well as to reach an understanding of factors which determine the patterns of spatial distribution of biodiversity (Elith et al. 2006; Ricklefs 2004). In general, occurrence data for the great majority of species are scarce and of presence-only since they generally come from random samplings that study flora and fauna. Therefore, determining the species distribution using data generated in such manner is inadequate for many applications (Cortés & Herrera 2011). Spatial distribution studies attempt to provide predictions of the distribution of species by connecting their presence with environmental factors. These have been applied in the study of relationships between environmental parameters and species richness (Herrera & Cortés 2010; MacNally & Fleishman 2004) and invasion by non-native species (Goolsby 2004). The present work attempts to analyze a large quantity of data compiled through flora and fauna studies in order to improve current knowledge of species distribution.

To this end, location data (latitude and longitude) for approximately 500 grass species have been obtained from floristic and diversity studies from the States of Chihuahua, Durango, and Zacatecas (Herrera 2001; Herrera & Peterson 2007; Herrera & Cortés 2009, 2010; Herrera et al. 2010; Cortés & Herrera 2011; Herrera et al., in prep.). This information was compiled and used to determine the climatic requirements for growth of the grass species. From these, a subset of 4 grasses from north central Mexico were chosen: 3 native and 1 introduced non-native species. The known distribution data of these 4 species indicate that they occupy diverse ecosystems, allowing the testing of the hypothesis that potential distribution of plants can be determined based on the climatic factors of the physical environment.

MATERIALS AND METHODS

Digital geo-referenced data of the selected grasses (*Muhlenbergia peruviana, Bouteloua gracilis, Muhlenbergia*

porteri, and *Melinis repens*) collected in the study area were analyzed with Geographic Information Systems (GIS) software, specifically the DIVA-GIS 7.1.7.2 version (http://www.diva-gis.org/), and GVSIG 1.9 for Vista (http://www.gvsig.org/), using geo-statistics maps of the States of Chihuahua, Durango, and Zacatecas (INEGI geo-statistics framework) together with Bioclimatic data of 30-second arc resolution from the Worldclim database (http://worldclim.org/current). The GIS software packages were developed for the analysis of species diversity and distribution in order to clarify geographical, ecological, and genetic standards (Hijmans et al. 2004) and contain the necessary algorithms to generate the required data in a simple manner.

The study area encompasses the territory of the States of Chihuahua, Durango, and Zacatecas in the north central Mexico, occupying approximately 446,000 km^2 (Fig. 1) located between the extreme coordinates 21°02'24" to 31°46'48"N and 109°04'12" to 100°44'24"W.

This area is also located within the physiographical provinces of the Sierra Madre Occidental and Sierras del Norte, as well as partially within the Mesa del Centro (INEGI 2003b). As such, the topography of the study area is highly varied and rugged with altitude variations between less than 500 m and up to 3200 m. Its latitude position, the distance to and influence of the maritime zone, and the topographical characteristics of this zone determine strong variation in climatic factors such as temperature and precipitation. Within this region are low-altitude areas with an annual temperature ranging between 24 to 26°C and high-altitude areas with annual temperatures ranging between 8 and 10°C. In terms of precipitation the study area has dry zones with little annual precipitation (200 mm) as well as sub-humid zones that have an annual precipitation between 1000 and 1500 mm. Interrelations between these and other factors cause the study area to have varied plant communities and soil cover from zones with pine and oak forests to grasslands and xerophilus scrubs (microphyll desert scrub, rosette desert scrub, crassicaule scrub), as well as small pockets dominated by halophilous scrub communities or halophilous grasslands, due to salty soils (INEGI 2003a).

The potential distribution analysis was carried out using a subset of four (out of 500) species belonging to diverse environments in order to determine the potential distribution and climatic characteristics of the distribution area. A total of three native species were selected, *Muhlenbergia peruviana* from temperate semiarid forests; *Bouteloua gracilis* from grasslands; *Muhlenbergia porteri* from the xeric region; as well as one nonnative introduction, *Melinis repens* (Zizka rose Natal grass). The data used to carry out our analysis came from specimens kept at several herbaria in Mexico (CHAPA, CIIDIR, ENCB, HUAA, IEB, MEXU, SLPM) as well as abroad (TAES, US) that had been included in previous floristic inventories of the study area (Herrera 2001; Herrera & Peterson 2007; Herrera & Cortés 2009, 2010; Herrera et al. 2010; Cortés & Herrera 2011).

Potential species distribution prediction was carried out using the Bioclim model included in the Diva-GIS program applied to Global Climate Data from the WorldClim bioclimatic database (http://www.worldclim.org/current). In brief, the Bioclim model identifies patterns of geographical distribution of species from 19 bioclimatic variables (contained in the database) and determines areas where species could thrive. Unlike other models, this model uses presence-only data (Kenth & Carmel 2011; Rodríguez-Soto et al. 2011), characterizing the areas which are within the climate cover that have environmental characteristics similar to those occupied by the species under study. Bioclim can be used to describe the environment in which a certain species has been previously found in order to identify other areas where the species can live in the current condition as well as to identify areas where the same species could be present if the climate landscape alters.

The WorldClim bioclimatic database is a set of global climate layers (raster format) with a spatial resolution of about one kilometer. It can be used to generate maps or create a spatial model in GIS or other computer software. This database was generated by the interpolation of observed and representative data from the years 1950 to 2000 (Hij-mans et al. 2005).

Creation of prediction maps of distribution.—Potential distribution maps were generated for the four grass species with the Bioclim model, initially classifying the area into the following categories of probability of occurrence: Unsuitable, Low (0–3.5 percentiles), Medium (3.5–5 percentiles), High (5–10 percentiles), Very High (10–20 percentiles), and Excellent (20–34 percentiles). In order to determine the main climatic characteristics relevant to the species distribution, the maps were remodelled so that only cells/areas with high, very high and excellent probability were shown.

Creation of temperature and precipitation maps for each species.—Maps of the mean annual temperature and annual precipitation of the study area were generated from the climate database using Diva-GIS functions. Afterwards, using overlapping map functions, annual precipitation and mean annual temperature maps were generated for the high-probability distribution areas of each species.

Crossing of temperature and precipitation maps.—The annual precipitation and mean annual temperature maps were cross-mapped so that for every species, each high-probability distribution map cell also showed the precipitation and temperature values. Furthermore, the cell frequency for the various precipitation and temperature values was obtained.

RESULTS

Maps of the predicted distribution of four grass species were generated with the Diva-GIS Bioclim algorithm. The selected species were *Muhlenbergia peruviana, Muhlenbergia porteri, Bouteloua gracilis,* and *Melinis repens,* which were chosen because they have been collected in different ecosystems and our results show the variety of climate conditions in which they can develop. Said maps show the level of probability of occurrence for each of the species in the study area (Guarino et al. 2002; Hijmans et al. 2004).

Muhlenbergia peruviana is listed as a species commonly distributed in pine-oak forest communities and the potential distribution map that was generated (Fig. 2) shows that areas of the Sierra Madre Occidental have greater probability of occurrence for this species.

When the mean annual temperature and total precipitation maps of high, very high and excellent probability of distribution areas of *M. peruviana* were obtained, we found that this species is located in areas with a relatively low mean annual temperature between 12 and 17°C, particularly at 14°C. Furthermore, the annual precipitation ranged between 600 and 1000 mm, notwithstanding the fact that the largest area was comprised in places with 600 mm (Tables 1 and 2). With this in mind, it is possible to establish that the distribution of *M. peruviana* is within areas with low temperatures and relatively high precipitation.

The potential distribution map of *Bouteloua gracilis*, which is known to be mainly distributed in natural grasslands and within some xerophilus scrubs (Fig. 3), shows a large area with high to excellent values of potential distribution.

The distribution area of *B. gracilis,* with greater likelihood values, had annual precipitations ranging from 400 to 800 mm, with an average of 560 mm although the most common precipitation values (mode) were 500 and 600 mm (these had the highest percentage of surface area). The mean annual temperature established in our model showed a range between 13 and 19°C, with an average of 16.2°C and a mode located at 17°C.

The potential distribution map of *Muhlenbergia porteri* (Fig. 4), which is known to be present within xerophilus scrubs (Fig. 4), placed this species within the driest regions of the study area.

The area with the highest predicted distribution of *M. porteri* had a mean annual temperature ranging between 12 and 21°C, with the mean located at 17.8°C and the mode at 18°C, while the annual precipitation ranged between 300 and 900 mm with a mean centered at 482 mm and a mode of 400 mm.

Climatic requirements for each of the three native species are summarized in Table 3, showing that, as expected, they belong to different ecosystems.

The potential distribution map of the nonnative introduced grass *Melinis repens* (Fig. 5) showed that it had the smallest area of likely distribution. It is possible that these results are influenced by the fact that this species was represented in low numbers with all collections used in this study.

Nevertheless, the distribution area with the highest likelihood of having *Melinis repens* showed mean annual temperatures ranging between 14 and 18°C, with an average of 16°C and a mode also at 16°C. Also, the annual precipitation reached an average of 609 mm, with a range between 500 to 800 mm and a mode of 600 mm.

DISCUSSION

Results from previous inventories of grass species carried out in the arid and semiarid regions in northern Mexico (Herrera 2001; Herrera & Peterson 2007; Cortés & Herrera 2010; Herrera & Cortés 2010, 2011; Her-

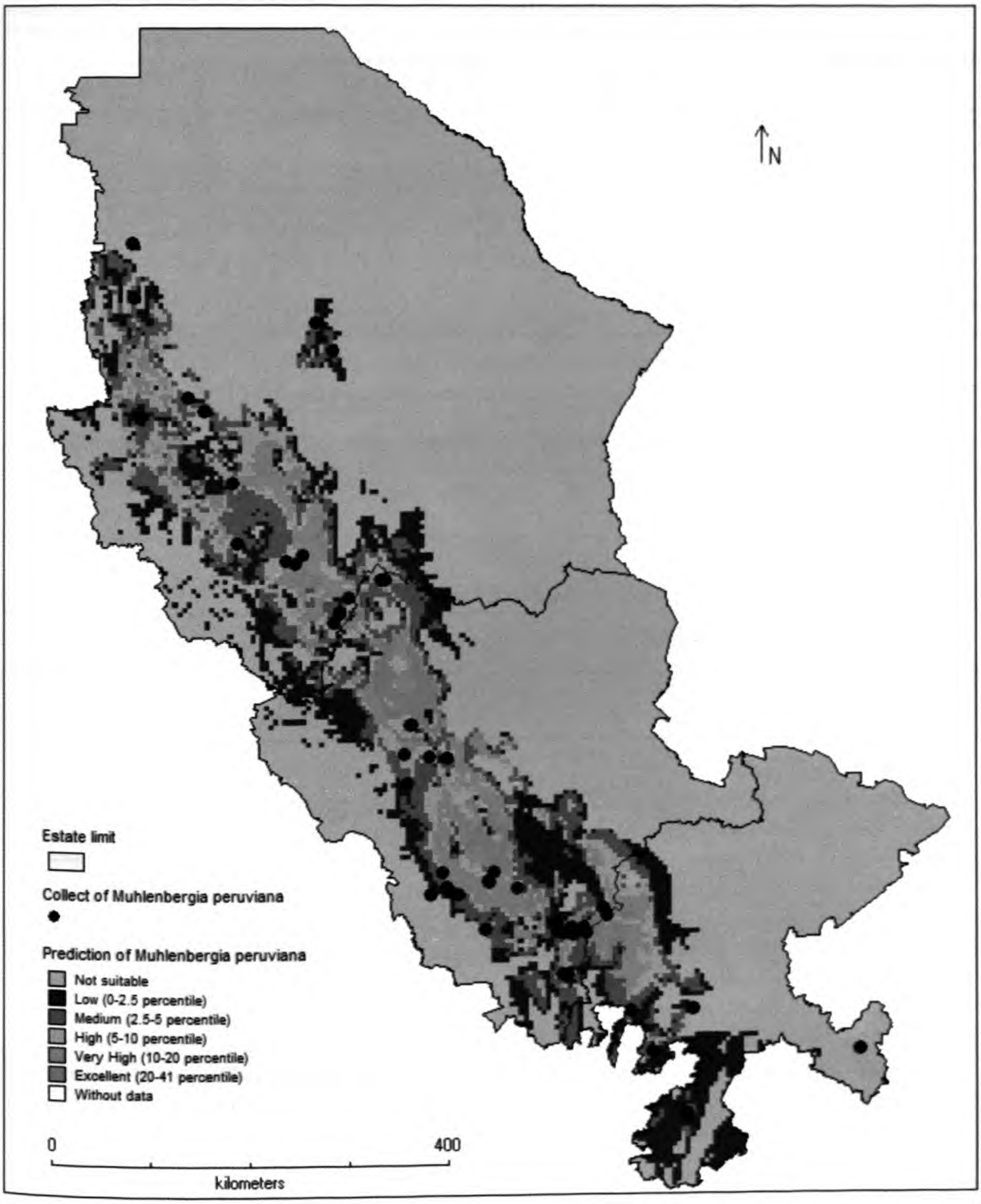


FIG. 2. Map of the potential distribution of *Muhlenbergia peruviana* obtained with Bioclim.

rera et al. 2010; Herrera et al. in prep) allowed us to construct probable distribution maps of close to 500 species of which the actual areas of distribution are known; this work shows the results from a subset of four selected species. The distribution of grass species in northern Mexico is mainly determined by climatic factors (Rzedowski 1978); therefore it can be assumed that this same analysis applied to the remainder of the grass species within this area has a very high probability of increasing our knowledge on their potential distribution.

TABLE 1. Proportion (%) of cells/areas with high probability of distribution of *Muhlenbergia peruviana* with regards to mean annual temperature and total precipitation.

Annual precipitation (mm)	Annual mean temperature (° C)											
	11	12	13	14	15	16	17	18	19	20	21	TOTAL
300	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	1	0	0	0	0	0	0	1
600	0	1	3	8	12	10	2	0	0	0	0	36
700	0	2	4	8	5	1	0	0	0	0	0	20
800	0	4	5	7	3	1	0	0	0	0	0	20
900	0	4	7	4	2	1	0	0	0	0	0	18
1000	0	1	2	1	1	0	0	0	0	0	0	5
TOTAL	0	12	21	28	24	13	2	0	0	0	0	100

TABLE 2. Annual precipitation and mean temperatures associated with potential distribution of *Muhlenbergia peruviana*.

	Num. of cells	Minimum	Máximum	Mean	Standar desv.	Moda
Annual precipitation	2449	500	1000	733	142	600
Annual mean temperature	12	17	14	1.32	15	

TABLE 3. Comparison of annual precipitation and mean temperature requirements of the three native species analyzed.

	Muhlenbergia peruviana	*Bouteloua gracilis*	*Muhlenbergia porteri*
Annual mean precipitation	733 mm	560 mm	482 mm
Annual mean temperature	14°C	16.2°C	17.8°C

In this study we modeled the potential distribution of four grass species from the arid and semiarid regions in northern Mexico, allowing us to predict the area in which it is more likely to find each of them as well as to determine the main climatic characteristics necessary for each species to be present.

The maps of potential distribution of *Muhlenbergia peruviana, Bouteloua gracilis, Muhlenbergia porteri,* and *Melinis repens,* generated with the Bioclim model using 19 bioclimatic variables, show the probability of distribution of these species within the study area in regard to their bioclimatic characteristics. These maps allowed us to determine the annual precipitation and mean annual temperature conditions in which each species has been found. The possible distribution areas can be considered to be critical for further fieldwork as these show similarities in the main climatic characteristics with those areas where these species are distributed.

Our analysis clearly shows that the three native species that were selected grow under very different climatic conditions, lending support to our initial decision of selecting species from different ecological regions. Nevertheless, *Melinis repens* (the introduced species) was shown to share a large ecological niche with *Bouteloua gracilis* (the grasslands species) since the former has climatic requirements similar to those of the latter. This fact could mean that this African species would not be able to invade other communities, such as forests or xerophytic scrubs, only posing a problem for grasslands. With our model it is possible to appreciate the actual distribution shared between a native species and an introduced species.

The replacement of native species with less desirable introduced species affects biodiversity. The hypothesis that biodiversity has an influence on productivity and stability of the grassland ecosystem has been previously tested in European grasslands by Hector et al. (1999) and in North American grasslands by Tilman et al. (1997). Both groups agree that the loss of biodiversity directly affects productivity and stability of grasslands.

One of the grasses that was studied in our work, *Melinis repens* (Zizka rose Natal grass), is an invasive species and the prediction of critical areas of future expansion is an important issue in order to prevent an in-

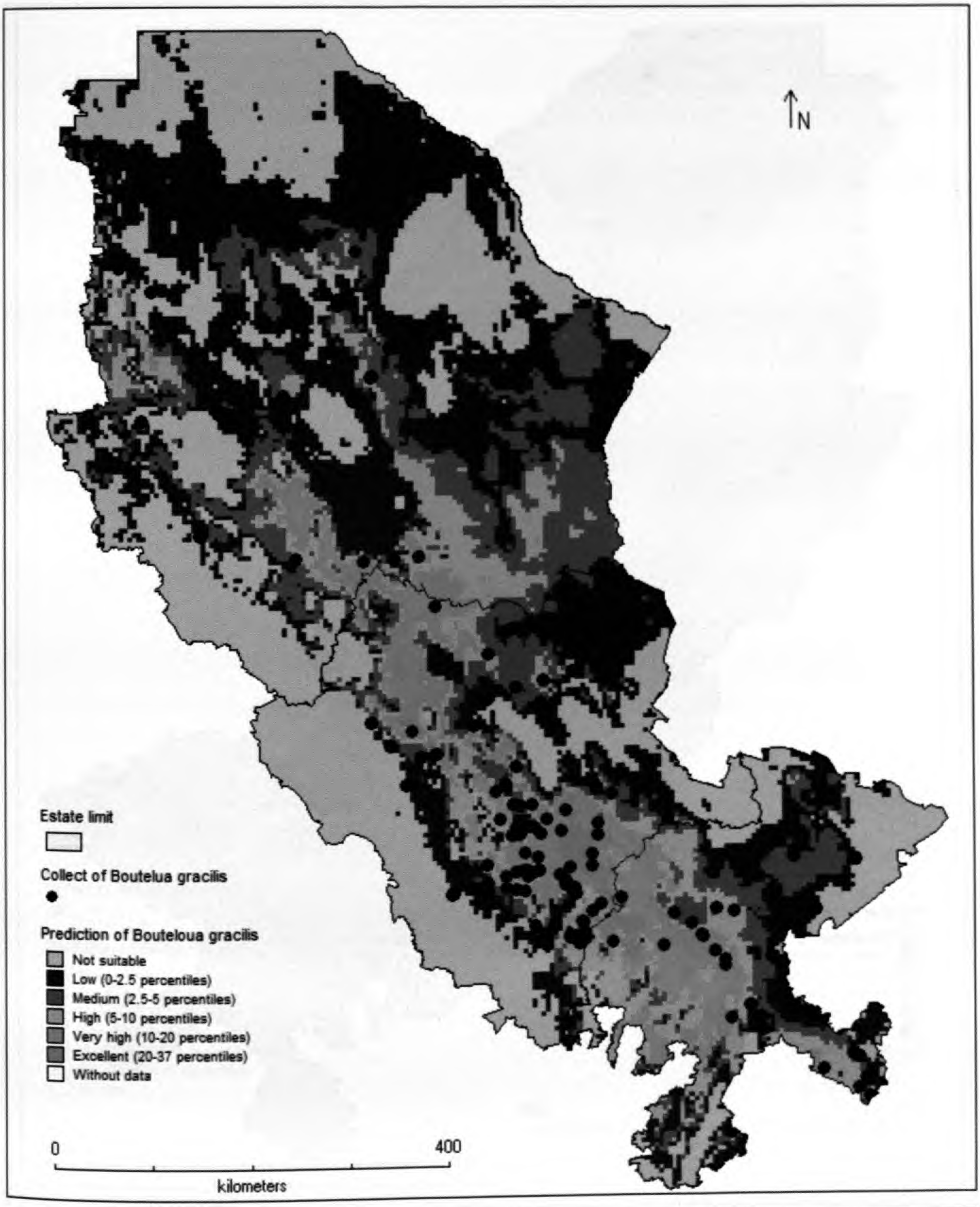


FIG. 3. Map of the potential distribution of *Bouteloua gracilis* obtained with Bioclim.

vasion and later displacement of native grassland species in Mexico. *Melinis repens* is an African grass that was recently introduced into Mexico (less than 50 years ago), first found at the edge of roads, a fact that possibly helped this species to spread, and it now invades and displaces native species in grasslands in northern Mexico (Herrera Arrieta et al. 2011; Herrera Corral et al. 2011). This grass is highly aggressive and this characteristic could be allowing it to increase its cover and dominate the distribution areas of *Bouteloua gracilis* (blue grass).

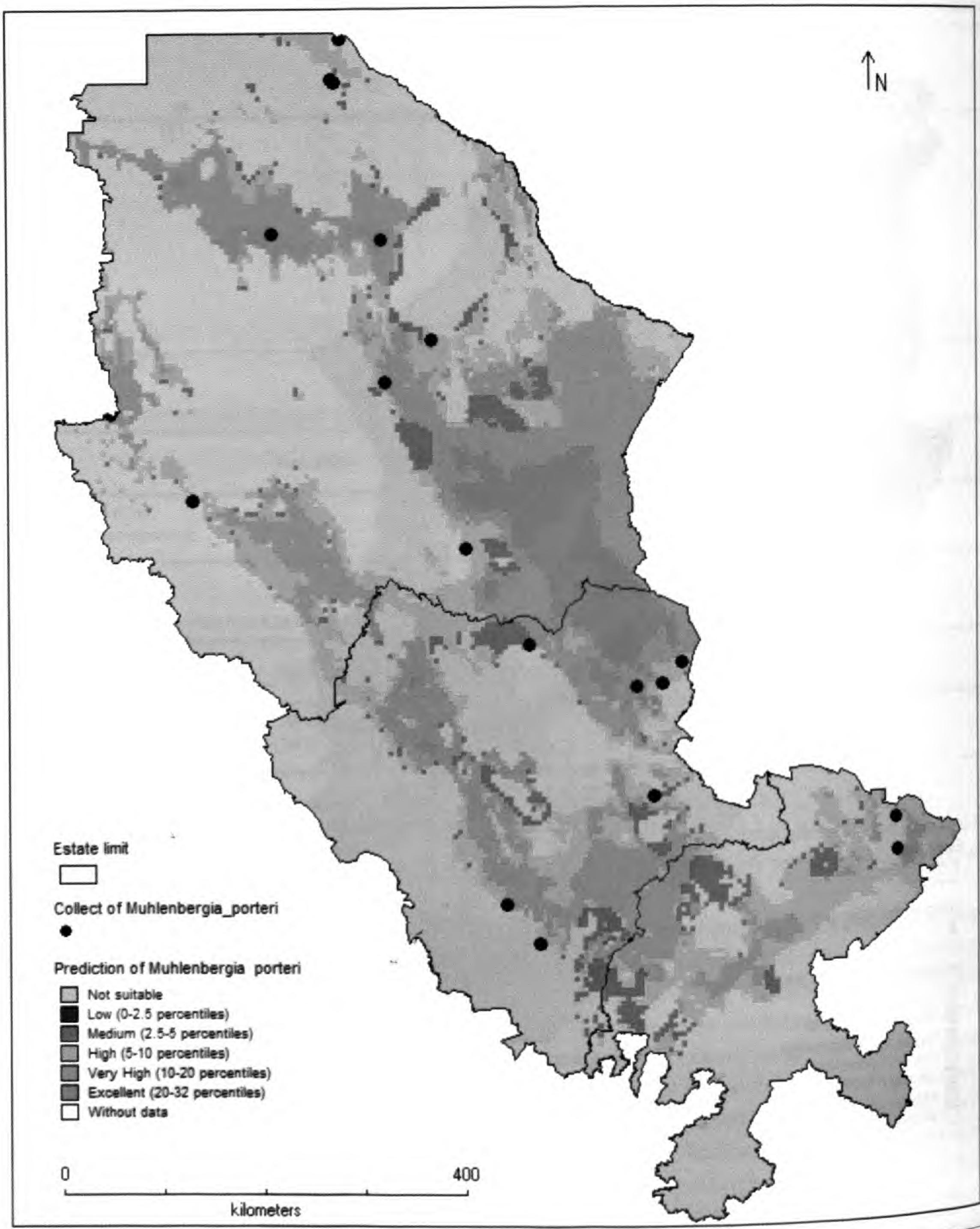


Fig. 4. Map of the potential distribution of *Muhlenbergia porteri* obtained with Bioclim.

However, Figure 5 shows that climatic conditions could be containing Zizka rose Natal grass from spreading into every space that blue grass now occupies within these grasslands (see Fig. 4).

CONCLUSIONS

With this study we have shown that it is possible to carry out prediction modeling of the potential distribution or ecological niche of grass species based upon presence-only data (Kent & Carmel 2011; Rodríguez-Soto et al. 2011) that can be obtained from specimens collected with floristic inventory purposes.

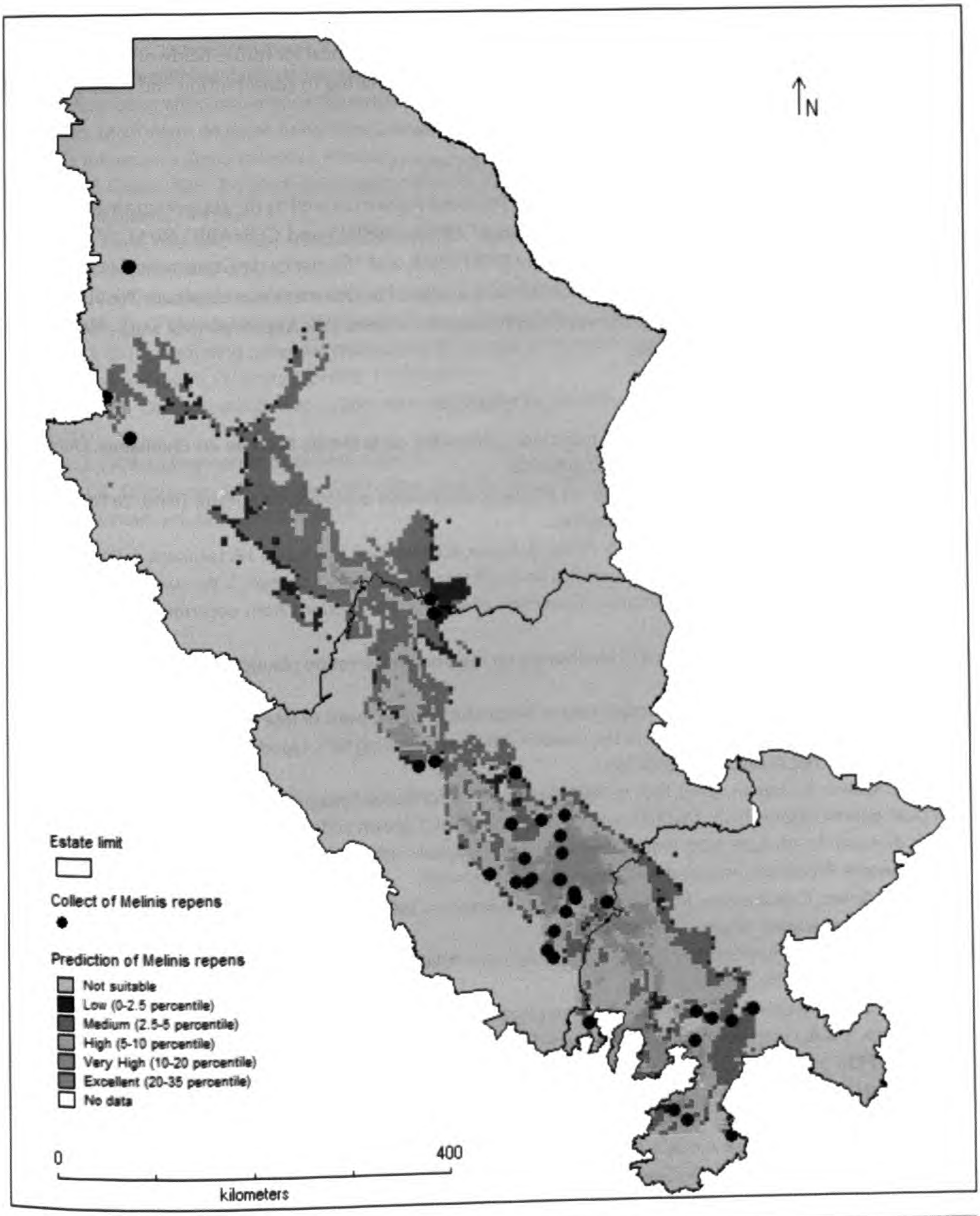


FIG. 5. Map of the potential distribution of *Melinis repens* obtained with Bioclim.

Also, this study demonstrates that the overlap in distribution between native and invasive species can be shown, providing valuable information that can be used for preventing the spread of invasive species and the displacement of native species. We also uncovered evidence that it is possible that climatic requirements are preventing the expansion of the African-introduced species *Melinis repens* (Zizka rose Natal grass), although it has spread into grasslands in northern Mexico during the last 40 years.

Our work provides information on the potential distribution of grass species that could be useful in future biological assessments as well as for determining areas that are critical for future fieldwork. Furthermore, studies similar to this one should provide support for decisions relating to conservation and management of grasses in Mexico.

ACKNOWLEDGMENTS

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JOURNAL NOTICE

DOUGLAS J. FUTUYMA, H. BRADLEY SHAFFER, AND DANIEL SIMBERLOFF, EDS. 2012 (Dec). **Annual Review of Ecology, Evolution, and Systematics, Volume 43.** (ISSN: 1543-592X; ISBN: 978-0-8243-1443-9, hbk). Annual Reviews, Inc., 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303, U.S.A. (**Orders:** www.AnnualReviews.org, service@annualreviews.org, 1-800-523-8635, 1-650-493-4400). $89.00 indiv., 485 pp., 7 5/8" × 9 3/8".

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A BASELINE VASCULAR PLANT SURVEY FOR OCMULGEE NATIONAL MONUMENT, BIBB COUNTY, MACON, GEORGIA

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ABSTRACT

Ocmulgee National Monument is administered by the National Park Service, United States Department of the Interior, and comprises 283.9 ha (701.5 acres) in two disjunct land parcels located in Macon, Bibb County, central Georgia. The park is significant for earthen mounds and other archeological sites associated with the Native American Mississippian cultures that settled along the Ocmulgee River. A floristic survey was conducted to provide Park Service personnel with a baseline vouchered plant species checklist, supplemented with salient information such as relative abundance, locality data, and general community type. Identifications of vouchers from prior surveys were also verified and incorporated into the annotated list that now totals 436 species of vascular plants. The five largest families are Poaceae (53 spp.), Asteraceae (36 spp.), Cyperaceae (33 spp.), Fabaceae (21 spp.), and Rosaceae (18 spp.). According to state rankings, one special concern species, *Cayaponia quinqueloba*, occurs within the study area, and approximately 24 percent of the non-cultivated flora is exotic. A vouchered checklist of vascular plants and descriptions of the general plant communities are included, as well as a list of unvouchered species previously reported from the park.

RESUMEN

El Ocmulgee National Monument está administrado por el Servicio de Parques Nacionales, del Departamento de Interior de los Estados Unidos, y comprende 283.9 ha (701.5 acres) en dos parcelas disjuntas localizadas en Macon, Bibb County, Georgia central. El parque es significativo por los montículos de tierra y otros lugares arqueológicos asociados a las culturas nativas americanas del Mississippi cultures que se asentaron a lo largo del río Ocmulgee. Se realizó un estudio florístico para aportar al personal al servicio del parque un catálogo de especies de plantas con testigos, suplementada con información relativa a su abundancia, datos de la localidad, y tipo general de comunidad. También se verificaron las identificaciones de testigos de estudios anteriores que se incorporaron al catálogo que totaliza ahora 436 especies de plantas vasculares. Las cinco familias más grades son Poaceae (53 spp.), Asteraceae (36 spp.), Cyperaceae (33 spp.), Fabaceae (21 spp.), y Rosaceae (18 spp.). De acuerdo con la legislación del estado una especie protegida, *Cayaponia quinqueloba*, vive en el área de estudio, y aproximadamente el 24 por ciento de la flora no-cultivada flora es exótica. Se incluyen un catálogo de las plantas vasculares y descripciones de las comunidades vegetales, así como una lista de las especies citadas previamente del parque.

INTRODUCTION

Study Area

The "fall line" in Georgia is a prominent geological boundary ca. 32 km (20 mi) wide extending from Augusta southwest to Columbus (Fig. 1A) and represents the Mesozoic shoreline of the Atlantic Ocean. The ancient beach demarcates the flat and sandy upper Coastal Plain to the south from the rolling rocky hills of the Piedmont to the north and separates significantly different plant and animal communities. As a consequence, the diverse habitats within this narrow transition zone are characterized by a rich variety of flora and fauna (Wharton 1978). Settlements developed where rivers descend along the relatively steep slope of the fall line, forming rapids or waterfalls that were used to generate power, and provided natural stopping points for travel

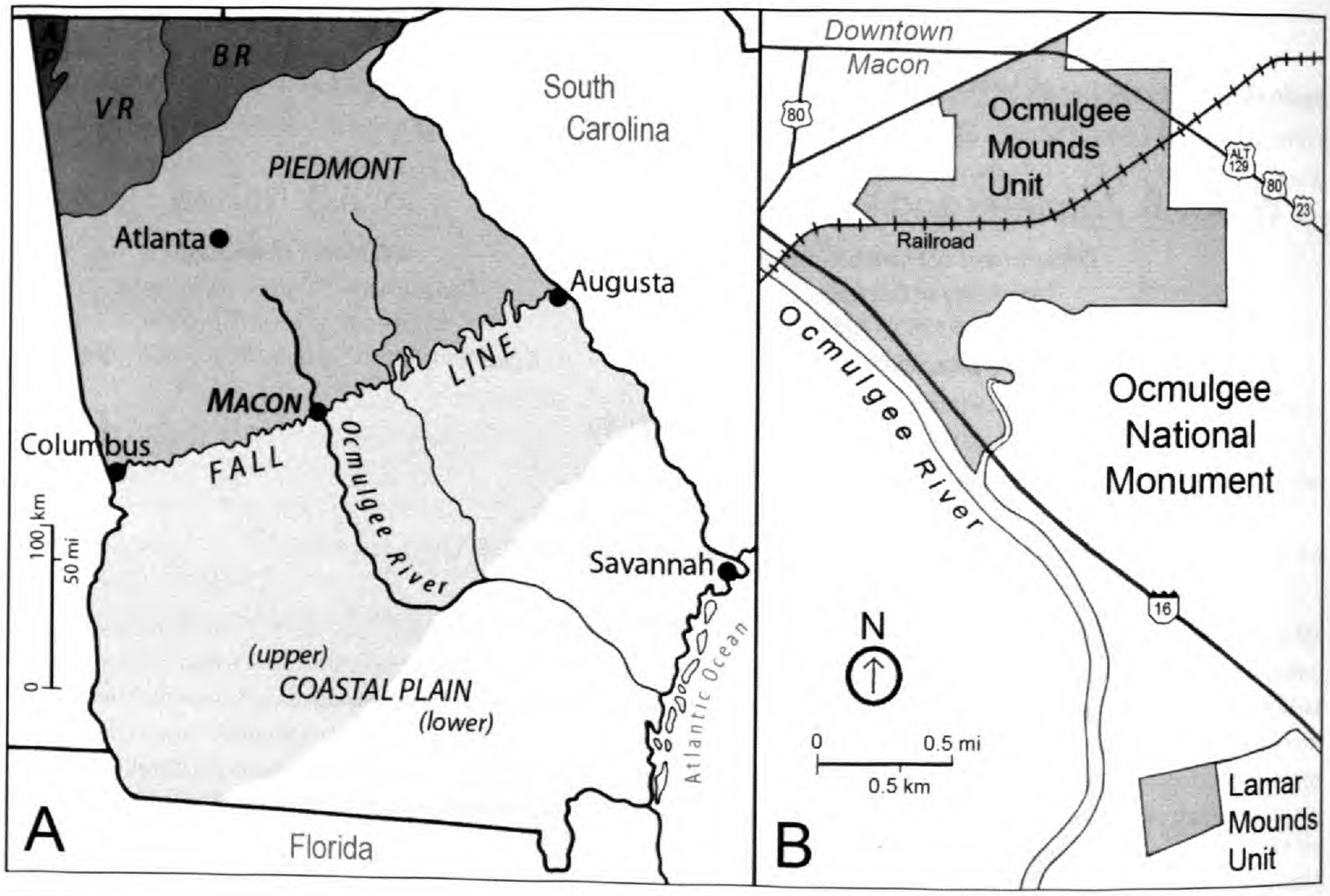


Fig. 1. Location of Ocmulgee National Monument. A. Physiographic regions of Georgia, the fall line, and the Ocmulgee River. Abbreviations: AP = Appalachian Plateau, BR = Blue Ridge, VR = Valley and Ridge. B. Detail of eastern Macon, Georgia, showing location of the two land parcels comprising Ocmulgee National Monument: the Ocmulgee Mounds and Lamar Mounds units. A modified by WBZ from Wharton (1978); B modified by WBZ from Wheeler (2007) and NPS (2012d).

and commerce. An example is the city of Macon, founded at the fall line of the Ocmulgee River. The river, whose Native American name (Okmulgee) translates as "where the water boils up," provides the principal watershed for much of the Piedmont and Coastal Plain of central Georgia (Fig. 1A).

Ocmulgee National Monument (OCMU), administered by the National Park Service (NPS, U.S. Department of the Interior), is located along the Ocmulgee River in eastern Macon (Bibb County) at the fall line (NPS 2012a). The park comprises 283.9 ha (701.5 acres) in two separate land tracts (Figs. 1B and 2): the much larger main park unit, Ocmulgee Mounds (265.7 ha, 656.5 acres), and the small detached parcel ca. 3.2 km (2 mi) south, the Lamar Mounds unit (18 ha, 45 acres). OCMU has significant archeological sites including nine earthen mounds associated with two Native American Mississippian cultures that settled along the river prior to European contact (Hally 1994; see "Brief History of OCMU with Emphasis on Land Use" below). Due to the rich cultural resources, OCMU is listed on the National Register of Historic Places and has been designated a Traditional Cultural Property (Wheeler 2007).

The study area is characterized by hot, humid summers and mild winters (National Weather Service 2012). The mean annual temperature is 16° C (60.0° F), with January the coldest month at 1.4° C (34.5° F), and July, the warmest at 33.2° C (91.8° F). Mean annual precipitation is 114.3 cm (45.0 in) per year. January has the highest average precipitation with 12.7 cm (5.0 in), and October, the lowest with 6.0 cm (2.37 in).

Ocmulgee Mounds unit.—The main park unit (Macon Plateau site or "Ocmulgee Old Fields;" coordinates 32.838194°, -83.602124°) is adjacent to the eastern side of downtown Macon and is bordered to the southwest by the Ocmulgee River, and to the south, by Walnut Creek (Figs. 1B and 2A). The park is bisected by the Norfolk Northern Railroad. Emery Highway (U.S. 80E) cuts across the northeastern corner of the property, and Interstate 16 passes through its southwestern border, parallel to the Ocmulgee River. The ca. 9 km (5.5 mi)

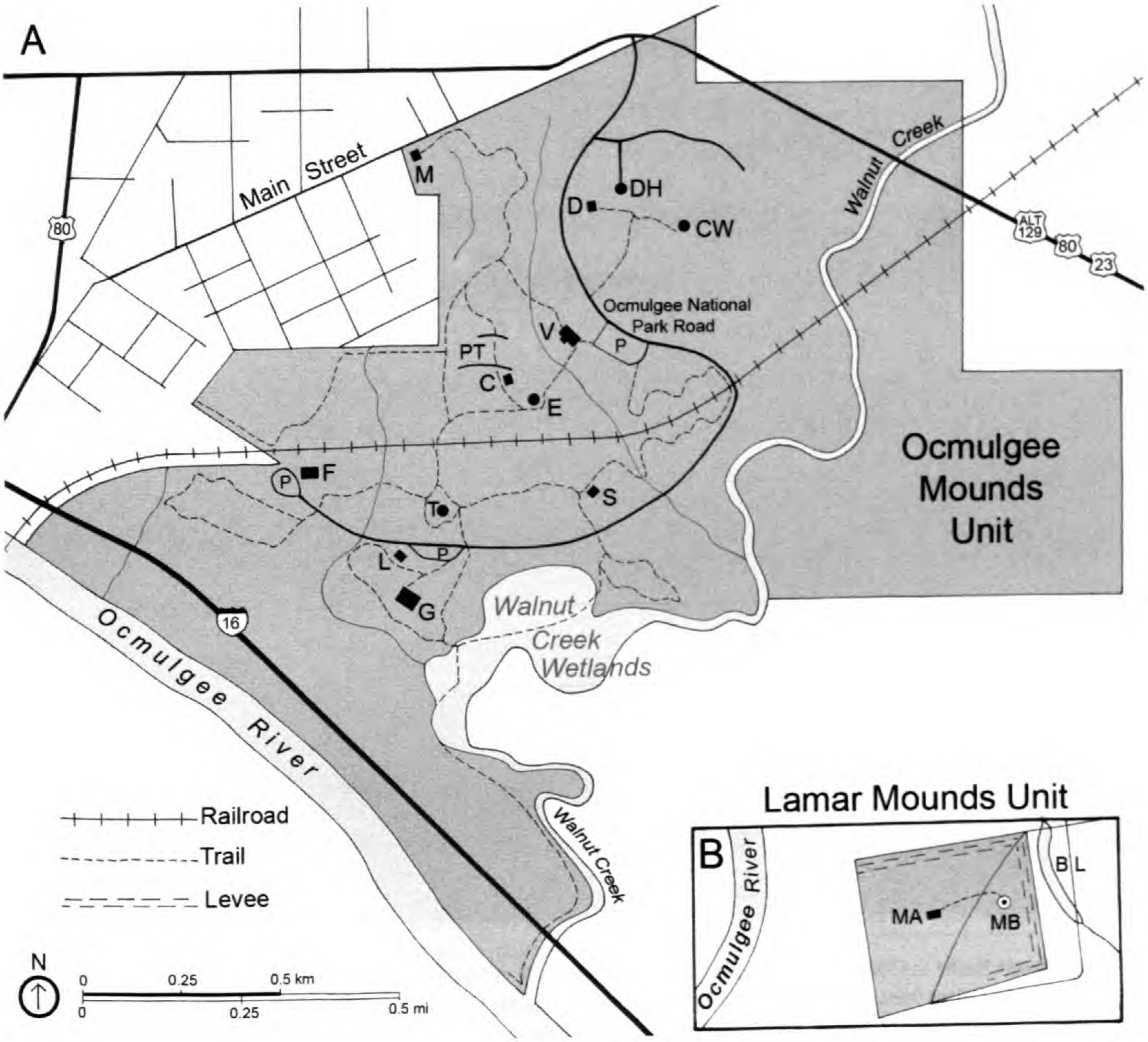


FIG. 2. Map of Ocmulgee National Monument, showing trails and locations of major cultural features. **A.** Ocmulgee Mounds unit, the main park. **B.** (inset). Lamar Mounds unit. Abbreviations: BL = Black Lake, C = Cornfield Mound, CW = Civil War earthwork, D = Dunlap Mound, DH = Dunlap House, E = Earthlodge, F = Funeral Mound, G = Great Temple Mound, L = Lesser Temple Mound, M = McDougal Mound, MA = Mound A (pyramidal mound), MB = Mound B (circular mound with spiral ramp), P = parking lot, PT = prehistoric trenches, S = Southeast Mound, T = trading post site, V = Visitor Center. A modified by WBZ from NPS (2005); B modified by WBZ from Wheeler (2007) and unpublished NPS map (G. LaChine, pers. comm.).

of hiking trails traverse upland forests and fields and pass along the swamps and open wetlands associated with the river and its tributary, Walnut Creek.

The most prominent landscape features at the Ocmulgee Mounds site are the seven rectangular earthen mounds that rise up to 17 m (55 ft; Greater Temple Mound, Fig. 3) above the relatively flat topography of 85–119 m (280–390 ft; Marsh 1986). Other historic resources date from early European settlement to more modern times, including a late seventeenth century British fort and trading post site, a Civil War gun emplacement, and a restored antebellum residence (Dunlap House). The Visitor Center includes a museum with exhibits and a major archeological collection with emphasis on the Early Mississippian culture that flourished in the main park parcel from 900 to 1100 AD. The park's natural and cultural resources attract about 123,000 visitors per year (NPS 2012b).

Lamar Mounds unit.—This isolated part of OCMU (Lamar Mounds and Village site; coordinates 32.812562°, -83.591580°) is located between the Ocmulgee River and Interstate 16, ca. 5 km (3 mi) southeast of



Fig. 3. Great Temple Mound and Walnut Creek wetlands. View of the eastern side of Great Temple Mound on a bluff overlooking the Walnut Creek wetlands (foreground) along Opelofa trail, 9 April 2009. The flat–topped pyramid, the largest of the earthen mounds, has a 91 × 82 m (300 × 270 ft) base and is 27 m (90 ft) tall on the terraced side shown, facing the wetland. The mound rises 17 m (55 ft) from the flat mounds area plateau to the north. Photo credit: W.B. Zomlefer.

downtown Macon (Fig. 1B). The property is in swampland slightly elevated from the surrounding floodplain (ca. 85 m, 280 ft) and an oxbow lake (Black Lake) nearby to the east (Fig. 2B; Wheeler 2007). An unfinished levee, constructed in the late 1930s to protect the site from flooding, borders the northern, eastern, and part of the southeastern sides of the property. The unit is the type site of the Lamar culture (Late Mississippian, 1350–1600 AD; Williams 1999) and comprises a palisaded village area (8.7 ha, 21.5 acres) surrounding two large earthen mounds: a rectangular (pyramidal) mound (Mound A in Figs. 2B and 4), 10.7 m (35 ft) tall, and an unusual circular mound with a spiral ramp (Mound B, 6.1 m [20 ft] tall). Each mound is enclosed by a locked chain-link fence. The Lamar Mounds unit has difficult access via a county road and an overgrown foot trail and is open to the public via guided tours on a very limited basis.

Brief History of OCMU with Emphasis on Land Use

Based on archeological evidence, Ocmulgee National Monument was occupied continuously by a series of native North American tribes for ca. 12,000 years before European contact in the mid-seventeenth century (summaries in Pope 1956; Marsh 1986; Hally 1998; NPS 2005; Wheeler 2007; Williams 2008). The most significant cultural period began when the early Mississippians (900–1100 AD) migrated to the area from the central Mississippi River Valley. This sophisticated and stratified society built a town (Ocmulgee Fields) supported by an agricultural economy managed by master farmers along the Ocmulgee River bottomlands. Their ceremo-

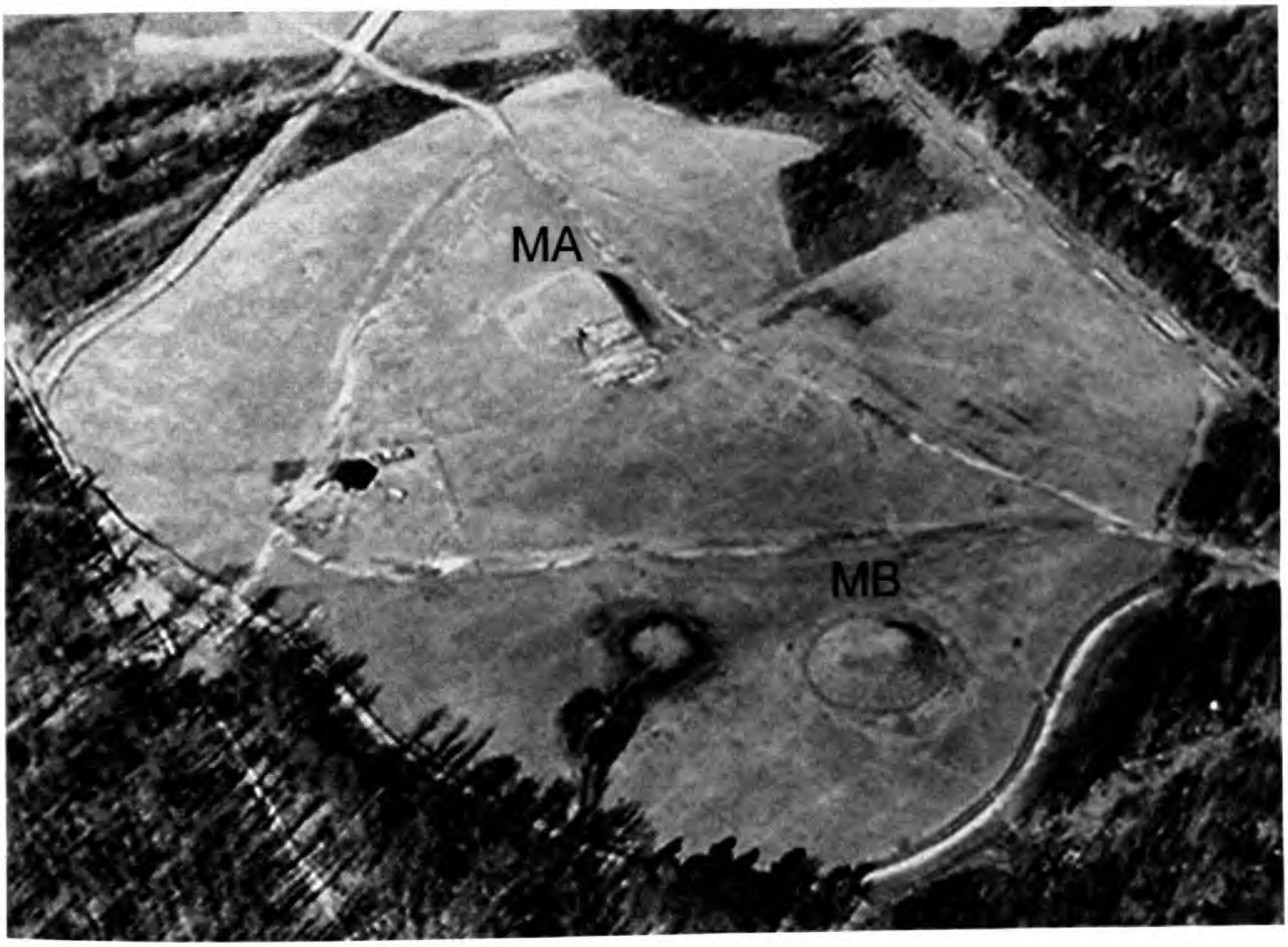


Fig. 4. Aerial view of excavation at the Lamar Mounds and Village Site, 1934. Today the area is covered by dense floodplain forest with an almost impenetrable understory dominated by *Ligustrum sinense*. Abbreviations: MA = Mound A; MB = Mound B (note spiral ramp). From the Ocmulgee National Monument collection; used with permission and courtesy of the National Park Service (A. Bates, pers. comm.).

nial complex included several structures that dominate the landscape today, including a circular earth lodge and seven massive flat-topped pyramidal earthworks that served as temple platforms and burial mounds (Figs. 2A and 3).

By 1350 AD, the Ocmulgee Fields declined as a ceremonial center, and a new culture, the Lamar or Late Mississippians, coalesced among people who lived in the swamps ca. 3.2 km (2 mi) downstream. One of their major centers is now protected as the Lamar Mounds and Village site (Figs. 1B, 2B, and 4). Represented by vestiges of a stockade surrounding two temple mounds, this site includes a unique circular mound with a spiral ramp (Figs. 2B and 4). The spread of introduced European disease led to eventual decline in the population, and by 1650 the remnants of the culture had relocated westward to the Chattahoochee River (Williams & Shapiro 1990).

Descendants of these Lamar (designated "Creek" or "Muscogee" by the European settlers) returned to Ocmulgee Fields in 1690 to re-establish the town ("Okmulgee Town") and to trade with the British who had built a trading post and fort near the sacred mounds (Fig. 2A). The Creeks were later (1717) expelled from the area after losing a war with the British over land rights. After the Revolutionary War, the new state of Georgia obtained concessions to Creek tribal lands in 1826, following a series of contentious treaties (see Pope 1956; Wheeler 2007). The acreage was incorporated into the new city of Macon, established in 1828.

For the next century, agriculture and industry accelerated the progressive degradation of the natural and cultural resources of the site (Froeschauer 1989; Wheeler 2007). The main park area was a large plantation by the mid-1850s. Grazing removed understory vegetation in the forested areas of Walnut Creek, and intense ag-

ricultural production around the mounds eroded topsoil that accumulated downriver at the Lamar site. The Central of Georgia Railroad constructed two railway lines though "Ocmulgee Old Fields," clearing vegetation and removing much of Lesser Temple Mound and Funeral Mound in the process. After the Civil War, a brick factory, fertilizer plant, and dairy farm were in operation at the site, and clay was mined from deep pits near Great Temple Mound. By the 1920's, the Ocmulgee mounds had become a popular recreation area for Macon residents, and activities such as motorcycle racing (on the slopes) further eroded the earthworks. A large portion of McDougal Mound was used as fill for constructing Emery Highway.

A group of concerned local citizens and politicians successfully secured New Deal funding for archeological studies, organized by the Smithsonian Institution. The massive excavations, conducted from 1933–1942 by the Civilian Conservation Corps (CCC), stripped most of the vegetation at both sites (e.g., Fig. 4) to reveal prehistoric landscapes and invaluable artifacts. The success of the federally sponsored study in addition to strong local support for historical preservation resulted in the establishment of Ocmulgee National Monument by Presidential Proclamation in 1936 (Marsh 1986; Wheeler 2007). Under the jurisdiction of the National Park Service, CCC workers constructed roads, trails, utilities, parking lots, and the Visitor Center for the new park. Loblolly pine (*Pinus taeda*) and Bermuda grass (*Cynodon dactylon*) were planted to control erosion.

More recently, natural resources have been heavily impacted by encroaching urbanization, particularly the construction of the Macon Levee (in 1950) on the western side of the river and of Interstate 16 (in the 1960s; Fig. 1B), which extensively changed the hydrology at both park units (Burkholder et al. 2010). One significant consequence was a massive flood in 1994 that inundated hardwood forest and created the Walnut Creek wetlands, now a permanently flooded area (Figs. 2A, 3, and 5). Currently, the rest of the main park consists of forested "natural" zones surrounding mowed lawns protecting the mound areas. The Lamar Mounds unit is covered by dense floodplain forest that is managed on a minimal maintenance schedule with trail and mounds occasionally cleared of vegetation. The NPS continues to negotiate for acquisition of up to 14,000 acres of Ocmulgee Old Fields eligible for the National Register as Traditional Cultural Property due to the significance to the Creek people (David 2012).

Floristic Surveys of OCMU

A few unvouchered lists of plant species for the Ocmulgee National Monument and surrounding areas had been produced for various park reports (e.g., Froeschauer 1989; Puckett 1997). In 1999, the National Park Service inaugurated a long-term ecological inventory and monitoring program to establish baseline data on park ecosystems for resource management decisions (see Fancy et al. 2009). As part of that initiative in the southeastern United States (DeVivo et al. 2008), a comprehensive and vouchered floristic survey of OCMU was conducted by Gaddy and Nelson (2004). They collected 447 specimens from July 2002 to November 2004 and also obtained 31 vouchers from informal 1986–1987 surveys by John D. Shepherd and his students at Mercer University in Macon, Georgia. The most recent specimen verifications and supplemental collections in 2008–2009 by Zomlefer and associates enhance previous surveys with the goal of generating an accurate vouchered species list as a reference for on-going invasive species control and park-wide vegetation community mapping and research projects (e.g., DeVivo et al. 2011).

MATERIALS AND METHODS

The first author led 4 field trips for one year (27 May, 25 July, and 1 October 2008; 9 April 2009; *Zomlefer 2091–2136, 2249–2268, 2275–2292, 2359–2403*) to collect plant specimen vouchers using standard field and herbarium techniques (under collecting permit # OCMU-2008-SCI-0005). One follow-up trip was conducted on 7 August 2012 to confirm vegetation community types. The GA Herbarium team also verified determinations of vouchers from previous surveys of the park (*Nelson*, *Gaddy*, and *Shepherd* collections), including 70 unidentified specimens as well as a voucher of *Salpichroa origanifolia* sent to GA for identification in November 2010 by Theresa L. Hall, Interpretive Ranger at Ocmulgee National Monument. The complete set of mounted vouchers for the park (610 specimens) is deposited at GA Herbarium. The floras of Radford et al. (1968) and Weakley (2011) were primary sources for plant identification, supplemented by Cronquist (1980), Godfrey

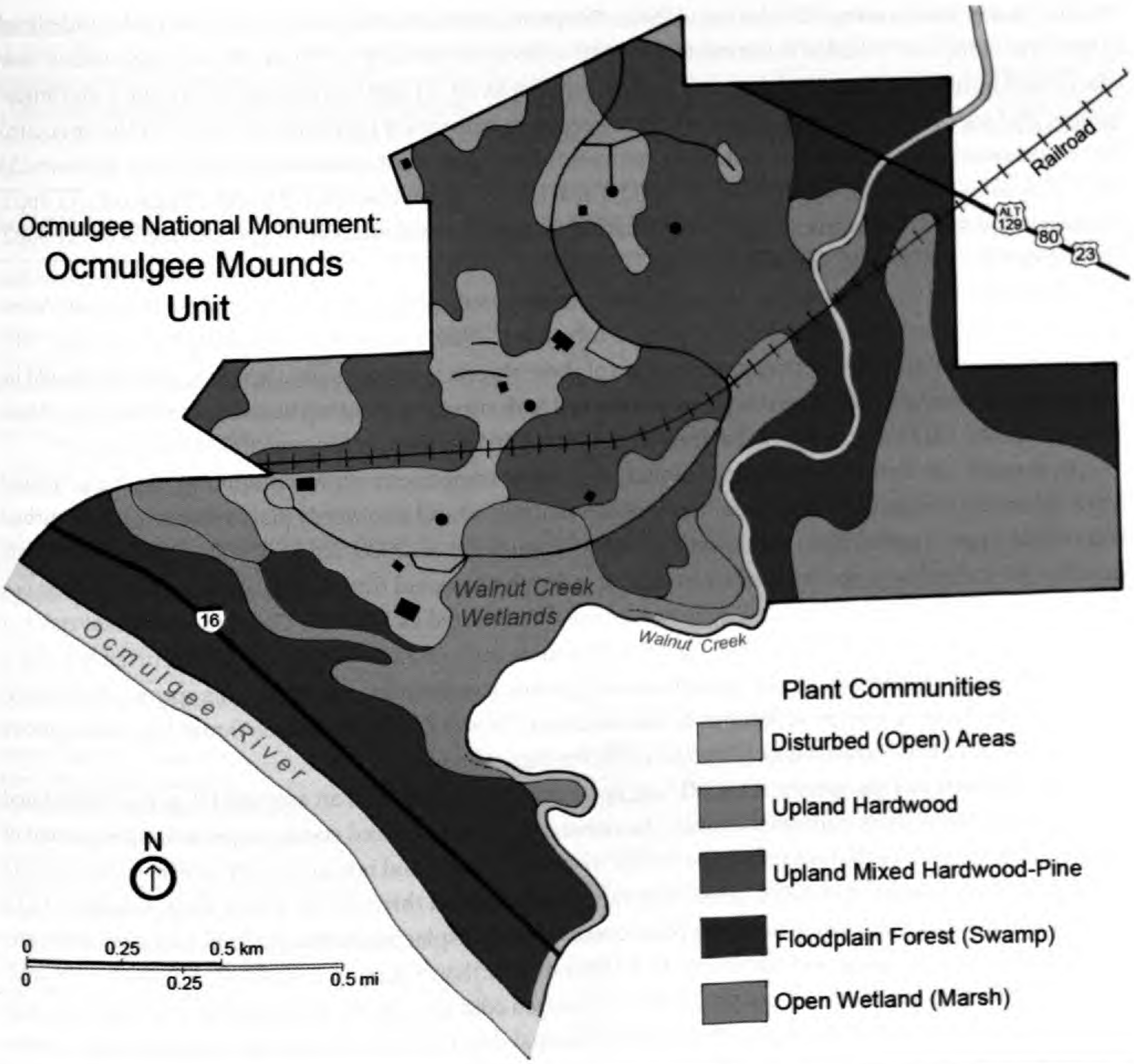


Fig. 5. General vegetation map of the Ocmulgee Mounds unit. Locations of major cultural features and Ocmulgee National Park Road provided for reference (see Fig. 2A). Modified and updated from Froeschauer (1989) by WBZ from field observations (W.B. Zomlefer and B.L. Wichmann, pers. obs.), specimen locality data, Google Earth©, and unpublished aerial imagery maps (CIR 1999 [color infrared] and NAIP 2010 [National Agriculture Imagery Program]) provided by the NPS (G. LaChine, pers. comm.).

(1988), Godfrey and Wooten (1979, 1981), Isely (1990), Wunderlin and Hansen (2000, 2011), and appropriate volumes of the *Flora of North America* (FNA 1993+). Infraspecific status was designated when practical keys (utilizing discrete characters appropriate for our specimens) were available. The list of unvouchered plant sight records (Appendix 1) was compiled from unpublished reports and an NPS species database (NPS 2012c) with the nomenclature and taxonomy updated using the *Integrated Taxonomic Information System* online database (ITIS 2012) and Weakley (2011). The format of this report incorporates standards recommended for floristic studies by Palmer and Richardson (2012).

RESULTS

Floristics

The "Annotated Checklist of Vascular Plant Taxa" is the complete flora for Ocmulgee National Monument represented by vouchers in GA Herbarium. The current survey comprised 131 new numbered collections of

vascular plants representing 123 species; of these, 58 species are new vouchered taxa for the park (underlined in the "Annotated List"). Added to the existing OCMU collections, the tally is 436 species (610 specimens) now vouchered for this flora in three major plant groups: monilophytes (11 spp.), gymnosperms (2 spp.), and angiosperms (423 spp.). Included in this total are three species in cultivation (indicated as "CULT" in the annotated list) or persisting from cultivation but likely not naturalized. The most numerous families are: Poaceae (53 spp.), Asteraceae (36 spp.), Cyperaceae (33 spp.), Fabaceae (21 spp.), Rosaceae (18 spp.), Fagaceae (11 spp.), Lamiaceae (10 spp.), Rubiaceae (9 spp.), Polygonaceae (8 spp.), Convolvulaceae (7 spp.), Onagraceae (7 spp.), Plantaginaceae (7 spp.), and Sapindaceae (7 spp.).

Appendix 1 is a compilation of 189 additional unvouchered species cited for Ocmulgee National Monument in NPS databases and unpublished reports (Froeschauer 1989; Puckett 1997; Burkholder et al. 2010; NPS 2012c). Without preserved specimens, verification of these reports is not possible; therefore, this list should be referenced with caution. Based on our previous national park survey work using unvouchered lists (e.g., Zomlefer et al. 2008, 2012), we predict that at least 20 percent of this list likely represents misidentifications.

In general, the flora of Ocmulgee National Monument comprises a representation of the basic habitat types of central Georgia (see "Plant Communities" section below) and also weedy plants common in disturbed areas of the upper Coastal Plain and lower Piedmont (Zomlefer et al. 2008, 2012). The flora does not include any Georgia endemics or species ranked as state or federally protected (threatened, endangered, or rare; GA DNR 2010; USFWS 2012). However, *Cayaponia quinqueloba* is listed as a Special Concern species (at risk but not formally protected) by the GA DNR (2011) with a state rank of S2 (imperiled; 6–20 occurrences) and a global rank of G4 (apparently secure globally; no immediate conservation concern). This species was vouchered from the western margin of Walnut Creek wetlands (*Nelson 23064*; see Fig. 2A) and from the apex of Mound A at the Lamar Mounds unit (*Zomlefer 2259*; see Figs. 2B and 4).

One-hundred and six species at OCMU are non-native (indicated with an asterisk [*] in the "Annotated List"). Excluding the three cultivated exotics, the remaining 103 introduced species represent 23.6 percent of the flora. Thirty-seven of the non-native species are invasive (Table 1) and ranked in four categories by Georgia Exotic Pest Plant Council (GA-EPPC 2006) depending on perceived threat to the native flora: Category 1 (13 spp.; serious invasive extensively invading plant communities, displacing native species); Category 2 (9 spp.; moderate invasive, invading and displacing to a lesser degree than Category 1 species); Category 3 (8 spp.; minor invasive or potential threat not yet known, a threat in adjacent states); and Category 4 (8 spp.; naturalized in Georgia, generally not posing a threat but additional data needed). Most of these species were vouchered from disturbed areas of the park (indicated as "DA" in Table 1).

Currently, about 40 ha (100 acres) of OCMU have been successfully surveyed, treated, and managed for invasive plant species (G. LaChine, pers. comm.). For the past ten years, park personnel have been targeting the most prevalent and critical of these exotics (all ranked as Category 1): *Ailanthus altissima*, *Ligustrum sinense*, *Melia azedarach*, and *Pueraria montana*. A serious invasive of immediate concern and removal efforts, *Triadica sebifera*, has become widespread in the Walnut Creek wetlands area of the main park unit and is also present at the Lamar Mounds unit. Other exotics, such as *Lonicera japonica* and *Hedera helix*, have been eradicated whenever possible, especially from sensitive areas with cultural resources (NPS 2012d). In some areas, aquatic invasives *Alternanthera philoxeroides* (Category 1), *Murdannia keisak* (1), and *Myriophyllum aquaticum* (2) are becoming a management challenge (Burkholder et al. 2010). Control measures have not been instigated for the 20 non-native grass species (Wheeler 2007; G. LaChine, pers. comm.); eight of these are ranked as Category 2 or 3 (Table 1). In the main park unit, these exotics primarily occur intermixed with native grasses and planted *Cynodon dactylon* comprising the mowed lawns covering the mound areas.

Plant Communities

Ocmulgee National Monument has a long history of disturbance that has drastically altered the vegetation, especially over the last two centuries (see "Brief History of OCMU with Emphasis on Land Use"). The Ocmulgee Mounds unit now comprises grassy fields (around the mounds) surrounded by upland woods and forested or open wetland habitats (Fig. 5). The Lamar Mounds unit is swamp with some open disturbed areas bordering

TABLE 1. List of 37 non-cultivated exotic invasive (or potentially invasive) species vouchered for Ocmulgee National Monument, with rankings as assessed by the GA–EPPC (2006): Category 1 (serious invasive), Category 2 (moderate invasive), Category 3 (minor invasive or potential threat not yet known), and Category 4 (naturalized in Georgia, additional data needed). Habitats: DA = disturbed areas; FP = floodplain swamp; PM = pond/marsh (open water); UF = upland forest; hab? = habitat data not recorded on voucher specimen label. Abundance: c = common (generally abundant throughout a particular habitat); o =occasional (locally common and/or several individuals distributed within a habitat); i = infrequent (sporadic occurrence of a small number of individuals); r = rare (very few individuals); ab? = abundance data not recorded on voucher specimen label.

Species (Common Name)	Rank	Habitat; Abundance
Ailanthus altissima (Tree-of-heaven)	1	DA; o
Albizia julibrissin (Silktree)	1	DA, UF; ab?
Allium vineale (Field garlic)	4	DA, i
Alternanthera philoxeroides (Alligator-weed)	1	PM; o–c
Cynodon dactylon var. *dactylon* (Bermuda grass)	2	DA, c
Dioscorea polystachya (Cinnamon vine)	2	PM; ab?
Elaeagnus pungens (Thorny-olive)	2	UF; ab?
Eragrostis curvula (Weeping lovegrass)	3	DA; c
Hedera helix (English ivy)	1	UF; c
Ilex cornuta (Chinese holly)	4	DA; ab?
Jacquemontia tamnifolia (Jacquemontia)	4	DA; ab?
Lespedeza cuneata (Sericea lespedeza)	1	DA; c
Ligustrum japonicum (Japanese privet)	2	DA; o
Ligustrum sinense (Chinese privet)	1	FP, UF; c
Liriope spicata (Creeping lilyturf)	4	UF; i
Lonicera fragrantissima (Sweet breath-of-spring)	3	DA; i
Lonicera japonica (Japanese honeysuckle)	1	UF; o
Lygodium japonicum (Japanese climbing fern)	1	DA, PM; i–c
Melia azedarach (Chinaberry)	1	DA; ab?
Morus alba (White mulberry)	3	DA; r–c
Murdannia keisak (Marsh dewflower)	1	DA, FP, PM; c
Myriophyllum aquaticum (Parrot-feather)	2	PM; i–c
Nandina domestica (Sacred-bamboo)	2	DA, UF; ab?
Paspalum notatum var. *saurae* (Bahia grass)	2	DA; o
Paspalum urvillei (Vasey grass)	3	DA; o
Persicaria longiseta (Longbristle smartweed)	4	DA; c
Phyllostachys aurea (Golden bamboo)	2	DA; c
Poa annua (Annual bluegrass)	3	DA; o
Pueraria montana var. *lobata* (Kudzu)	1	DA; c
Schedonorus arundinaceus (Tall fescue)	3	DA; i–c
Sesbania punicea (Rattlebox)	2	PM; o
Sonchus oleraceus (Common sow-thistle)	4	DA; r
Sorghum halepense (Johnson grass)	3	DA; o
Stachys floridana (Florida betony)	3	DA; c
Triadica sebifera (Chinese tallow-tree)	1	FP, PM; i–c
Verbascum thapsus (Common mullein)	4	DA; r
Verbena bonariensis (Purpletop vervain)	4	DA; ab?
Wisteria sinensis (Chinese wisteria)	1	DA; ab?

the overgrown logging road and cleared mound areas (Fig. 2B). Below is a summary of the flora of these general community types based on Wharton (1978), Froeschauer (1989), specimen data, and field observations (W.B. Zomlefer & B.L. Wichmann, pers. obs.): upland forest (mixed hardwood and mixed hardwood–pine), swamp forest, open wetland, and disturbed areas. These categories, which may intergrade, are provided as a guide for placing plant species within the context of a habitat.

Upland Forests.—The forested uplands at the Ocmulgee Mounds unit (Fig. 5) have been modified by disturbance into secondary growth hardwood and mixed hardwood–pine (Wharton 1978; Burkholder et al. 2010). The dominants are oaks (e.g., *Quercus falcata*, *Q. nigra*, *Q. phellos*), hickories (e.g., *Carya glabra*, *C. ovata*), and loblolly pine (*Pinus taeda*); a few areas along the southeastern section of Ocmulgee National Monument Road are dominated by pine. Other codominant trees include *Acer* spp. (e.g., *A. floridanum*, *A. rubrum*), *Fagus*

grandifolia, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Magnolia grandiflora*, and *Ulmus americana*. The composition of the understory shrubs and shrubby trees vary according to the overstory and location in the park and commonly include *Aesculus pavia*, *Asimina parviflora*, *Calycanthus floridus*, *Carpinus caroliniana*, *Celtis laevigata*, *Cercis canadensis*, *Cornus florida*, *Crataegus* spp. (e.g., *C. spathulata*), *Diospyros virginiana*, *Ilex* spp. (e.g., *I. decidua*), *Ligustrum sinense*, *Prunus serotina*, and *Vaccinium arboreum*. *Gelsemium sempervirens*, *Hedera helix*, *Lonicera japonica*, *Smilax* spp. (e.g., *S. bona-nox*), *Toxicodendron radicans*, and *Vitis* spp. (e.g., *V. rotundifolia*) comprise some frequent vine species intertwined amongst the shrubs and over the ground cover.

Understory vegetation is much more diverse in the mixed hardwood forests than in those areas where pine predominates. The early spring flora species, inhabiting the forest floor before the hardwood canopy fully closes, include: *Erythronium umbilicatum*, *Hexastylis arifolia*, *Luzula echinata*, *Melica mutica*, *Myosotis macrosperma*, *Podophyllum peltatum*, *Polygonatum biflorum*, and *Viola sororia*. Woodland species such as *Asplenium platyneuron*, *Conoclinium coelestinum*, *Dichanthelium commutatum*, *Elephantopus carolinianus*, *Oplismenus hirtellus*, *Symphyotrichum* spp. (e.g., *S. pilosum*), and *Tipularia discolor* appear later in the season, especially under canopy openings such as trail sides.

Floodplain Forest.—Swamp or bottomland hardwood (floodplain, alluvial, or palustrine forest) consists of seasonally inundated, mesic lowland that generally remains moist throughout the year (Wharton 1978). At the Ocmulgee Mounds unit, this community type is associated with the Ocmulgee River and Walnut Creek in the southwestern and eastern sections of the park, mainly bordering open marshland (Figs. 2A and 5). The low-lying Lamar Mounds unit is almost entirely covered by dense floodplain forest (Williams 1999) since the partial levee (Fig. 2B) provides little protection from periodic flooding by the nearby Ocmulgee River (Fig. 1B).

Within the swamp forest, tall trees create a closed-canopy over an often impenetrable thicket of shrubby understory. Dominant trees usually include *Acer* spp. (e.g., *A. negundo*, *A. rubrum*), *Betula nigra*, *Fraxinus pennsylvanica*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Nyssa biflora*, *Platanus occidentalis*, *Quercus* spp. (e.g., *Q. nigra*), and *Ulmus americana*. Swamp communities at OCMU can also be characterized by the following co-dominants and/or understory woody species: *Alnus serrulata*, *Asimina parviflora*, *Bignonia capreolata*, *Carpinus caroliniana*, *Crataegus viridis*, *Itea virginica*, *Ilex* spp. (e.g., *I. vomitoria*), *Ligustrum sinense*, *Lonicera japonica*, *Ostrya virginiana*, *Pinus taeda*, *Salix caroliniana*, *Smilax* spp. (e.g., *S. laurifolia*), *Triadica sebifera*, *Toxicodendron radicans*, and *Vitis* spp. (e.g., *V. rotundifolia*). A relatively sparse understory of ferns, such as *Onoclea sensiblis* and *Woodwardia areolata*, and angiosperm species, such as *Arundinaria gigantea*, *Arisaema triphyllum*, *Commelina virginica*, *Juncus coriaceus*, *Justicia ovata*, *Leersia lenticularis*, *Lobelia cardinalis*, *Lycopus rubellus*, and *Pilea pumila*, may occur under openings in the bottomland canopy.

Open Wetlands.—Open wetland (or marsh) is a broad designation, here applied to aquatic areas at the Ocmulgee Mounds unit where the canopy is lacking or sparse and standing water is often present for at least part of the year. This habitat type is mainly associated with floodplain areas of the Ocmulgee River and its tributary, Walnut Creek (Fig. 5). The large marsh, Walnut Creek wetlands (Figs. 2A, 3, and 5), developed from hydrological changes caused by the construction of I-16 (Wheeler 2007; Burkholder et al. 2010). Prior to 1994, this open wetland was forested and seasonally flooded but the area now contains standing water all year.

In the marshy areas of this park unit, sedges and grasses predominate, including *Carex* spp. (e.g., *C. louisianica*, *C. lupulina*), *Cyperus* spp. (e.g., *C. erythrorhizos*, *C. retrorsus*), *Leersia virginica*, *Panicum anceps*, *P. rigidulum*, *Phanopyrum gymnocarpon*, *Rhynchospora globularis*, and *Scirpus cyperinus*. Floating aquatics include *Alternanthera philoxeroides*, *Myriophyllum aquaticum*, and *Najas minor*. Other common herbaceous species are *Erechtites hieraciifolius*, *Galium triflorum*, *Hydrocotyle verticillata*, *Iris hexagona*, *Juncus dichotomus*, *Ludwigia* spp. (e.g., *L. decurrens*), *Mikania scandens*, *Mimulus alatus*, *Murdannia keisak*, *Packera glabella*, *Persicaria* spp. (e.g., *P. hydropiperoides*), *Sagittaria latifolia*, *Saururus cernuus*, and *Typha latifolia*. *Berchemia scandens*, *Brunnichia ovata*, *Cephalanthus occidentalis*, *Cornus stricta*, *Forestiera acuminata*, *Hibiscus laevis*, *Rubus pensilvanicus*, *Sabal minor*, *Sambucus canadensis*, *Smilax* spp. (e.g., *S. glauca*), and *Vitis* spp. (e.g., *V. aestivalis*) are examples of common woody vines and scattered shrubs that occur along the margins of these open wetlands. The bordering areas may also comprise some tree species (such as *Acer floridanum*) and seedlings of *Triadica sebifera*.

Disturbed or Ruderal Areas.—This general category refers to cleared sections around public access areas (parking lots, roadsides, trails, railroad right-of-way) and mowed fields surrounding earthworks and other historic sites at the Ocmulgee Mounds unit (see Fig. 5). Disturbed areas in the Lamar Mounds swamp are restricted to the most exposed sites (cleared mounds and trail margins) and are characterized by species preferring damp habitat such as *Eupatorium serotinum*, *Hypericum mutilum*, *Perilla frutescens*, *Persicaria longiseta*, and *Smilax* spp. (e.g., *S. rotundifolia*).

In the main park, ruderal areas are characterized by a much more variable and diverse flora that includes many non-native and invasive species and a predominance of graminoids, including: *Andropogon* spp. (e.g., *A. glomeratus*), *Bromus racemosus*, *Cynodon dactylon*, *Dactylis glomerata*, *Danthonia spicata*, *Dichanthelium* spp. (e.g., *D. dichotomum*), *Echinochloa crusgalli*, *Eragrostis* spp. (e.g., *E. curvula*), *Festuca subverticillata*, *Lolium perenne*, *Panicum* spp. (e.g., *P. virgatum*), *Paspalum* spp. (e.g., *P. dilatatum*), *Setaria parviflora*, *Sorghastrum nutans*, *Sorghum halepense*, and *Vulpia myuros*. Asteraceae also comprise a large component, with common species such as *Ambrosia artemisiifolia*, *Erigeron strigosus*, *Eupatorium hyssopifolium*, *Gamochaeta* spp. (e.g., *G. pensylvanica*), *Helenium amarum*, *Hypochaeris radicata*, *Krigia virginica*, *Pityopsis graminifolia*, *Solidago altissima*, *Sonchus oleraceus*, and *Youngia japonica*. *Allium canadense*, *Chaerophyllum tainturieri*, *Glandularia pulchella*, *Houstonia pusilla*, *Ipomoea* spp. (e.g., *I. cordatotriloba*), *Lamium amplexicaule*, *Lespedeza cuneata*, *Plantago* spp. (e.g., *P. lanceolata*), *Polypremum procumbens*, *Stellaria media*, *Trifolium arvense*, *Vicia* spp. (e.g., *V. sativa*), and *Viola arvensis* are examples of other widespread ruderal herbs. The borders of these areas often include woody species such as *Morus rubra*, *Prunus serotina*, *Rubus trivialis*, *Toxicodendron radicans*, and *Vitis* spp. (e.g., *V. rotundifolia*).

DISCUSSION

OCMU Management Issues and Importance of Vouchers

Ocmulgee National Monument is a historically significant park that also supports diverse wildlife as part of a greenway corridor to other natural areas to the south (DeVivo et al. 2008). The biological and cultural resources of the park have been heavily impacted by surrounding urbanization and associated degradation of the Ocmulgee River watershed. Threats affecting the flora and fauna include air and water pollution, erosion, sedimentation, and invasive exotic species (Burkholder et al. 2010). The herbarium collection for OCMU serves as a baseline for monitoring these habitats, thus providing a valuable reference for natural resource management. Encroaching development threatens the native component of the OCMU flora while contributing to an increase in non-native and weedy species that require documentation. Continued inventory efforts should also concentrate on locating significant species—both native and exotic—previously reported in the park but not yet verified by voucher specimens (see Appendix 1).

ANNOTATED CHECKLIST OF VASCULAR PLANT TAXA

This list of 436 vascular plant species, representing 112 families, represents collections from Ocmulgee National Monument now deposited at the GA herbarium. Genera, species, and infraspecific taxa are alphabetical within each family under three major groups (monilophytes ["ferns and allies"], gymnosperms, and angiosperms). Family circumscriptions follow the following sources: Smith et al. (2006) for monilophytes; FNA (1993) for gymnosperms; and APG III (2009) for angiosperms. Scientific nomenclature follows ITIS (2012) and Weakley (2011). Common names are from Weakley (2011) when available, or from Wunderlin and Hansen (2011). The few synonyms included in brackets are alternate names used in NPS reports and databases.

Specimen notations: *G* = Gaddy (all s.n.) [GA accession number], *H* = Julie Howard (one specimen, *Salpichroa origanifolia*), *N* = Nelson, *S* = John D. Shepherd, *Z* = Zomlefer; underlined taxa = new vouchered taxa for the park by *Zomlefer*; * = exotic (ITIS 2012; Weakley 2011); invasive exotics (GA–EPPC 2006): [CAT 1] = Category 1, [CAT 2] = Category 2, [CAT 3] = Category 3, [CAT 4] = Category 4; rare plants: [Con] = species of special concern in Georgia (GA–DNR 2011); CULT = cultivated (i.e., planted on park grounds); (s) = sterile (non-reproductive) specimen. Locality/habitat data: LM = Lamar Mounds, DA = disturbed areas, FP = floodplain swamp, PM

= pond/marsh (open water), UF = upland forest, hab? = habitat data not recorded on specimen voucher label. Relative abundance: c = common (generally abundant throughout a particular habitat; species easily found), o = occasional (locally common and/or several individuals distributed within a habitat; species not too difficult to locate), i = infrequent (sporadic occurrence of a small number of individuals; species relatively scarce and not easily found), r = rare (very few individuals encountered), ab? = abundance data not recorded on voucher specimen label.

MONILOPHYTES ("FERNS AND ALLIES")

Aspleniaceae

Asplenium platyneuron (L.) Britton, Sterns & Poggenb., Ebony spleenwort; DA, UF; i-o; G s.n. [262100]; *N 23025; Z 2093*

Athyriaceae

Athyrium asplenioides (Michx.) A.A. Eaton [*A. filix-femina* (L.) Roth ssp. *asplenioides* (Michx.) Hultén], Southern lady fern; DA, PM, UF; i; *N 24364; S 4095*

Blechnaceae

Woodwardia areolata (L.) Moore, Netted chain fern; FP, PM, UF; o; *G s.n.* [262243] (s); *N 23021*

Dennstaedtiaceae

Pteridium aquilinum L., Bracken; UF; o; *N 23055*

Dryopteridaceae

Polystichum acrostichoides (Michx.) Schott, Christmas fern; LM: hab?, ab?; *S 4140* (s)

Lygodiaceae

**Lygodium japonicum* (Thunb.) Swartz, Japanese climbing fern; [CAT 1]; DA, PM; i-c; *G s.n.* [262175]; *N 24415; Z 2100*

Onocleaceae

Onoclea sensibilis L. var. *sensibilis*, Sensitive fern; PM; i; *G s.n.* [262188]

Osmundaceae

Osmunda spectabilis Willd. [*O. regalis* (Willd.) A. Gray var. *spectabilis* (Willd.) A. Gray], American royal fern; UF; i; *G s.n.* [262190] (s)

Osmundastrum cinnamomeum (L.) C. Presl, Cinnamon fern; DA; i; *N 23033*

Polypodiaceae

Pleopeltis polypodioides (L.) E.G. Andrews & Windham var. *michauxiana* (Weath.) E.G. Andrews & Windham [*Polypodium polypodioides* (L.) Watt], Resurrection fern; UF; c; *N 23052*

Thelypteridaceae

**Macrothelypteris torresiana* (Gaudich.) Ching, Mariana maiden fern; UF; i; LM: DA, FP; o; *N 23026; Z 2257*

GYMNOSPERMS

Cupressaceae

Juniperus virginiana L., Southern red cedar; UF; i; *G s.n.* [262160]

Pinaceae

Pinus taeda L., Loblolly pine; DA, UF; i; *G s.n.* [262196]; *N 23059* (s)

ANGIOSPERMS

Acanthaceae

Dicliptera brachiata (Pursh) Spreng., Branched foldwing; UF; LM: DA, FP; o; *G s.n.* [262136]; *Z 2387*

Justicia ovata (Walter) Landau var. *ovata*, Coastal plain water-willow; LM: DA, FP; i; *Z 2252*

Ruellia caroliniensis (J.F. Gmel.) Steudel, Wild petunia; DA; o; *N 23044*

Adoxaceae

Sambucus canadensis L., Common elderberry; FP, PM; c; *N 22976*

Viburnum nudum L. var. *nudum*, Southern wild raisin; FP; ab?; *G s.n.* [262236] (s)

Alismataceae

Sagittaria latifolia Willd., Broadleaf arrowhead; PM; i; *Z 2370*

Altingiaceae

Liquidambar styraciflua L., Sweet gum; UF; o; *G s.n.* [262166]

Amaranthaceae

**Alternanthera philoxeroides* (Mart.) Griseb., Alligator-weed; [CAT 1]; PM; o-c; *N 23065; Z 2117*

**Amaranthus viridis* L., Slender amaranth; DA; ab?; *G s.n.* [262097]

Chenopodium album L.; Lamb's-quarters; DA; r; *Z 2376*

**Dysphania ambrosioides* (L.) Mosyakin & Clemants [*Chenopodium ambrosioides* L.], Mexican-tea; DA; i; *N 24399*

**Gomphrena serrata* L., Arrasa con todo; DA; ab?; *N 22990*

Amaryllidaceae

Allium canadense L. var. *canadense*, Wild onion; DA; c; *Z 2131*

**Allium vineale* L., Field garlic; [CAT 4]; DA; i; *Z 2095*

Nothoscordum bivalve (L.) Britton, False garlic; DA; ab?; *N 23621*

Zephyranthes atamasca (L.) Herbert, Common atamasco-lily; PM, UF; i; *N 23703; Z 2403*

Anacardiaceae

Rhus copallinum L., Winged sumac; hab?; ab?; *G s.n.* [262212] (s)

Toxicodendron radicans (L.) Kuntze ssp. *radicans*, Eastern poison ivy; DA; ab?; *N 22932*

Annonaceae

Asimina parviflora Dunal, Small-flowered pawpaw; FP, UF; r-o; *N 23032* (s), *23054, 23684*

Asimina triloba (L.) Dunal, Common pawpaw; UF; i; *N 23063* (s)

Apiaceae

**Anthriscus caucalis* Bieb., Bur chervil; DA; i; *N 23675*

Chaerophyllum tainturieri Hook., Southern chervil; DA; o; *N 23660*

Sanicula canadensis L., Canadian black snakeroot; DA; i; *Z 2127*

Apocynaceae

Gonolobus suberosus (L.) R. Br. [*Matelea gonocarpos* (Walter) Shinners], Anglepod; DA, PM, UF; c-o; *N 22969; 23070; Z 2129*

Trachelospermum difforme (Walter) A. Gray, Climbing dogbane; FP; ab?; *N 22960*

Aquifoliaceae

Ilex ambigua (Michx.) Torr., Carolina holly; UF; ab? *N 23699, 24362*

**Ilex cornuta* Lindl. & Paxton, Chinese holly; [CAT 4]; DA; ab?; *N 24409*

Ilex decidua Walter, Possum-haw; DA, UF; o-c; *N 22927* (s), *22934, 23682*

Ilex opaca Aiton var. *opaca*, American holly; UF; i; *G s.n.* [262155]

Ilex vomitoria Aiton, Yaupon; DA, UF; ab?; *N 23004, 23655*

Araceae

Arisaema dracontium (L.) Schott, Green dragon; PM; ab?; *G s.n.* [262099] (s)

Arisaema triphyllum (L.) Schott, Jack-in-the-pulpit; LM: FP; ab?; *S 4147*

Araliaceae

Aralia spinosa L., Devil's-walking-stick; DA; ab?; *N 22994*

**Hedera helix* L., English ivy; [CAT 1]; UF; c; *N 23048* (s)

Hydrocotyle verticillata Thunb., Whorled marsh pennywort; PM; i; *G s.n.* [262153] (s)

Arecaceae

Sabal minor (Jacq.) Pers., Dwarf palmetto; PM; i; *N 22970; Z 2122*

Aristolochiaceae

Hexastylis arifolia (Michx.) Small [*Asarum arifolium* Michx.], Little brown jug; UF; i; *N 23686*

Asparagaceae

**Asparagus officinalis* L., Asparagus; DA; i; *N 22987, 24389; Z 2096* (s)

**Liriope spicata* Lour., Creeping lilyturf; [CAT 4]; UF; i; *Z 2290*

Polygonatum biflorum L. var. *biflorum*, Small Solomon's-seal; UF; i; *G s.n.* [262203]; *N 23701*

Yucca filamentosa L., Curlyleaf yucca; DA, UF; i; *G s.n.* [262245] (s); *N 23053* (s), *23694* (s)

Yucca gloriosa L., Mound-lily yucca; DA; ab?; *G s.n.* [262246] (s), [262247]

Asteraceae

Acmella repens (Walter) Rich. ex Pers., Creeping spotflower; LM: DA, FP; r; *Z 2256*

Ambrosia artemisiifolia L., Ragweed; DA; c; *G s.n.* [262098]; *N 24388*

Bidens bipinnata L., Spanish needles; hab?; ab?; *G s.n.* [262103]

Bidens discoidea (Torr. & A. Gray) Britton, Few-bracted beggar-ticks; FP; ab?; *G s.n.* [262104]

Bidens frondosa L., Devil's beggar-ticks; PM; i; *N 24412*

Brickellia eupatorioides (L.) Shinners [*Kuhnia eupatorioides* L.], False boneset; UF?; ab?; *S 4069*

Cirsium horridulum Michx. var. *horridulum*, Purple thistle; DA; ab?; *N 23716*

Conoclinium coelestinum (L.) DC., Mistflower; UF; ab?; *G s.n.* [262125]

Conyza canadensis (L.) Cronquist var. *canadensis*, Common horseweed; DA; i; *Z 2277*

Elephantopus carolinianus Raeusch., Leafy elephant's-foot; DA, UF; o; *G s.n.* [262142]; *Z 2286*

Erechtites hieraciifolius (L.) Raf., Fireweed; PM; c; *Z 2380*

Erigeron philadelphicus L. var. *philadelphicus*, Philadelphia-daisy; DA; i; *G s.n.* [262146]; *N 23709*

Erigeron strigosus Muhl. ex Willd. var. *strigosus*, Common rough fleabane; DA; o-c; *N 24402; Z 2110*

Eupatorium hyssopifolium L., Hyssopleaf eupatorium; DA; c; *Z 2291, 2365*

Eupatorium serotinum Michx., Late eupatorium; LM: DA; c; *Z 2385*

**Facelis retusa* (Lam.) Schultz-Bip., Trampweed; DA; i; *N 23642*

**Gamochaeta coarctata* (Willd.) Kerguélen, American everlasting; DA; i; *Z 2402*

Gamochaeta pensylvanica (Willd.) Cabrera, Pennsylvania everlasting; DA; o; *N 23639*

Gamochaeta purpurea (L.) Cabrera, Spoonleaf purple everlasting; DA; i; *G s.n.* [262148]; *Z 2393*

**Helenium amarum* (Raf.) H. Rock, Bitterweed; DA; o; *N 24403*

**Heterotheca latifolia* Buckley var. *latifolia*, Common camphorweed; DA; i; *N 24385*

**Hypochaeris radicata* L., Spotted cat's-ear; DA; ab?; *N 22998*

Iva annua L., Sumpweed; DA; c; *Z 2384*

Krigia virginica (L.) Willd., Virginia dwarf-dandelion; DA; o; *N 23650; Z 2392*

Lactuca floridana (L.) Gaertn., Woodland lettuce; DA, PM; i; *Z 2279*

Mikania scandens (L.) Willd., Climbing hempweed; FP, PM; c; *N 22968*

Packera glabella (Poir.) C. Jeffrey, Butterweed; FP, PM; o; *N 23707; S 3052*

Pityopsis graminifolia (Michx.) Small var. *graminifolia*, Narrowleaf silkgrass; DA; ab?; *G s.n.* [262199]

Solidago altissima L. var. *altissima*, Tall goldenrod; DA; i-c; *N 24380, 24387*

**Sonchus oleraceus* L., Common sow-thistle; [CAT 4]; DA; r; *Z 2101*

Symphyotrichum lanceolatum (Willd.) G.L. Nesom, White panicle aster; FP; i; *N 24372*

Symphyotrichum pilosum (Willd.) G.L. Nesom, White oldfield aster; UF; ab?; *S 4073*

Verbesina occidentalis Vellozo, Southern crownbeard; FP; ab?; *G s.n.* [262235]

Vernonia gigantea (Walter) Trel., Giant ironweed; FP, PM; i; *G s.n.* [262234]; *N 22979, 24377*

Xanthium strumarium L., Cocklebur; DA, FP; c; *N 24390*

**Youngia japonica* (L.) DC., Asiatic hawk's-beard; DA; ab?; *G s.n.* [262244]; *N 23672*

Berberidaceae

**Nandina domestica* Thunb., Sacred-bamboo; [CAT 2]; DA, UF; ab?; *G s.n.* [262183] (s)

Podophyllum peltatum Michx., May-apple; UF; o; *G s.n.* [262202]; *Z 2395*

Betulaceae

Betula nigra L., River birch; FP; o; *G s.n.* [262102] (s)

Carpinus caroliniana Walter, American hornbeam; UF; o; *N 23696*

Ostrya virginiana (Mill.) K. Koch, American hop-hornbeam; FP, UF; i-o; *G s.n.* [262191] (s), [262192] (s)

Bignoniaceae

Bignonia capreolata L., Cross-vine; DA; c; N 23712; Z 2394

Campsis radicans (L.) Seemans, Trumpet-creeper; PM; ab?; N 22975

Boraginaceae

**Heliotropium amplexicaule* Vahl, Wild heliotrope; DA; o; *Z 2275*

**Heliotropium indicum* L., Turnsole; FP; r; *N 24371*

Myosotis macrosperma Engelm., Bigseed forget-me-not; DA, UF; o; *N 23666, 23702; Z 2401*

Nemophila aphylla (Nutt.) R. & M., Smallflower baby blue eyes; DA; o-c; *N 23632; Z 2391*

Phacelia dubia (L.) Trel., Smallflower phacelia; DA; r-c; *G s.n.* [262195]; *N 23623, 23654, 23669; S 3018*

Brassicaceae

**Arabidopsis thaliana* (L.) Heynh., Mouse-ear cress; DA; ab?; *N 23673*

**Capsella bursa-pastoris* (L.) Medik, Common shepherd's purse; DA; o; *N 23679*

**Cardamine hirsuta* L., Hairy bittercress; DA; ab?; *G s.n.* [262107]

Cardamine pensylvanica Muhl. ex Willd., Quaker bittercress; DA; ab?; *N 23715*

Lepidium virginicum L. ssp. *virginicum*, Poor man's pepper; DA; i; *Z 2136*

**Lunaria annua* L., Annual honesty; DA; i; *N 23680*

Bromeliaceae

Tillandsia usneoides (L.) L., Spanish-moss; FP; o; *G s.n.* [262225]

Cactaceae

Opuntia humifusa Raf., Southern prickly-pear; DA; i-c; *N 23038* (s); *Z 2130*

Calycanthaceae

Calycanthus floridus L. var. *floridus*, Sweet-shrub; UF; i-o; *G s.n* [262105] (s);. *N 23056*

Campanulaceae

Lobelia cardinalis L., Cardinal flower; LM: FP; i; *Z 2389*

Lobelia elongata Small, Longleaf lobelia; PM; i; *G s.n.* [262167]

Triodanis biflora (Ruiz. & Pav.) Greene, Small Venus' looking-glass; DA; i; *N 23636*

**Wahlenbergia marginata* (Thunb.) DC., Southern rockbell; DA, UF; o; *G s.n.* [262241]; *N 23649*

Cannabaceae

Celtis laevigata Willd., Southern hackberry; DA, UF; r; *N 23671*; *G s.n.* [262122] (s)

Caprifoliaceae

**Lonicera fragrantissima* Lindl. & Paxton, Sweet breath-of-spring; [CAT 3]; DA; i; *N 23042* (s)

**Lonicera japonica* Thunb., Japanese honeysuckle; [CAT 1]; UF; o; *N 22925*

Valerianella radiata (L.) Dufr., Beaked cornsalad; DA; c; *N 23664*; *Z 2400*

Caryophyllaceae

**Cerastium glomeratum* Thuill, Sticky mouse-ear; DA; i; *N 23640*

**Stellaria media* (L.) Villars, Common chickweed; DA; i; *N 23622, 23629*

Celastraceae

Euonymus americanus L., Strawberry-bush; DA, UF; i; *G s.n.* [262147]; *N 23060*

Cistaceae

Lechea mucronata Raf., Hairy pinweed; DA; r; *N 24349*

Lechea racemulosa Michx., Illinois pinweed; DA; i; *N 24381*

Commelinaceae

Commelina virginica L., Virginia dayflower; FP; ab?; *N 22999*

**Murdannia keisak* (Hassek.) Hand.-Mazz., Marsh dewflower; [CAT 1]; DA, FP, PM; c; *G s.n.* [262182]; *N 23015* (s)

Tradescantia ohiensis Raf., Smooth spiderwort; UF; i; *G s.n.* [262226] (s)

Convolvulaceae

Cuscuta gronovii Willd., Common dodder; FP; i; *N 24365*

Dichondra carolinensis Michx., Carolina ponyfoot; DA; o; *N 23633*

Ipomoea coccinea L., Scarlet creeper; DA; ab?; *S 4103*

Ipomoea cordatotriloba Dennstedt var. *cordatotriloba*, Coastal morning-glory; DA; o; *G s.n.* [262154]; *Z 2369*

Ipomoea hederacea (L.) Jacq., Ivyleaf morning-glory; DA; o; *N 24395*; *Z 2378*

Ipomoea pandurata (L.) G.F.W. Mey., Wild sweet potato; DA; ab?; *N 22992*

**Jacquemontia tamnifolia* (L.) Griseb., Jacquemontia; [CAT 4]; DA; ab?; *S 4109*

Cornaceae

Cornus florida L., Flowering dogwood; UF; ab?; *G s.n.* [262126]

Cornus stricta Lam. [*C. foemina* Mill.], Southern swamp dogwood; PM, UF; o; *G s.n.* [262127] (s); *N 22962*

Nyssa biflora Walter, Swamp tupelo; FP; ab?; *G s.n.* [262185]

Nyssa ogeche Bartram ex Marshall, Ogeechee lime; FP; i; *G s.n.* [262186]

Cucurbitaceae

Cayaponia quinqueloba (Raf.) Shinners, Fivelobe melonleaf; Con; PM, LM: DA; r-o; *N 23064*; *Z 2259*

Melothria pendula L., Creeping cucumber; DA; ab?; *N 23007*

Cyperaceae

Carex abscondita Mack., Thicket sedge; UF; i; *N 23051*

Carex albicans Willd. ex Spreng. var. *australis* (L.H. Bailey) J. Rettig, Stellate sedge; UF; o; *G s.n.* [262108]

Carex amphibola Steud., Amphibious sedge; DA; i; *N 23663*

Carex blanda Dewey, Eastern woodland sedge; UF; i; *G s.n.* [262109]

Carex cephalophora Muhl. ex Willd., Oval-leaf sedge; DA; i; *N 23622*

Carex crebriflora Wiegand, Coastalplain sedge; UF; i; *G s.n.* [262110]

Carex crinita Lam., Fringed sedge; DA; o; *N 23016*

Carex debilis Michx., White-edge sedge; UF; i; *N 23697*

Carex digitalis Willd. var. *floridana* (L.H. Bailey) Naczi, Slender woodland sedge; DA; ab?; *N 23634*

Carex flaccosperma Dewey; Thinfruit sedge; LM: hab?; ab?; *S 4149*

Carex frankii Kunth, Frank's sedge; LM: DA, FP; o; *Z 2253*

Carex joorii L.H. Bailey, Joor'sedge; FP; i; *G s.n.* [262111]

Carex laxiflora Lam., Broad looseflower sedge; UF; i; *G s.n.* [262112]

Carex leavenworthii Dewey, Leavenworth's sedge; DA; ab?; *N 23653*

Carex louisianica L.H. Bailey, Louisiana sedge; PM; i; LM: DA, FP; o; *N 22945*; *Z 2251*

Carex lupulina Muhl. ex Willd., Hopsedge; PM; o; *N 22951*; *G s.n.* [262113]; *Z 2121*

Carex lurida Wahl., Shallow sedge; DA, UF; ab?; *N 23008*

Carex muehlenbergii Schkuhr ex Willd. var. *muehlenbergii*, Muehlenberg's sedge; DA; ab?; *N 23646*

Carex oxylepis Torr. & Hook., Sharpscale sedge; PM; ab?; *G s.n.* [262114], [262115]

Carex retroflexa Willd., Reflexed sedge; DA; i-o; *N 23661, 23668*

Carex seorsa Howe, Weak stellate sedge; PM; i; *G s.n.* [262116]

Carex striatula Michx., Lined sedge; UF; i; *G s.n* [262117]; *N 23691*

Carex texensis (Torr.) L.H. Bailey, Texas sedge; PM; ab?; *G s.n.* [262118]

Carex typhina Michx., Cattail sedge; PM, UF; i; *G s.n.* [262119]; *N 23041*

Carex vulpinoidea Michx., Fox sedge; DA, PM; ab?; *N 23711*

Cyperus echinatus (L.) Wood, Globe flatsedge; DA; c; *N 22953*

Cyperus erythrorhizos Muhl., Redroot flatsedge; FP, PM; c; *N 24375*

**Cyperus iria* L., Ricefield flatsedge; DA; i; *G s.n.* [262130]

Cyperus retrorsus Chapm., Pinebarren flatsedge; DA, PM; o; *G s.n.* [262131]; *N 22997*; *Z 2280*

Cyperus strigosus L., False nutsedge; DA; ab?; *G s.n.* [262132]; *N 23009*

Cyperus virens Michx., Green flatsedge; FP, PM; o; *G s.n.* [262133]; *N 22943*

Rhynchospora globularis (Chapm.) Small var. *globularis*, Globe beaksedge; FP, PM; ab?; *G s.n.* [262213]

Scirpus cyperinus (L.) Kunth, Woolgrass bulrush; FP, PM; o-c; *G s.n.* [262218]; *N 22967*; *Z 2278*

Dioscoreaceae

**Dioscorea polystachya* Tucz., Cinnamon vine; [CAT 2]; PM; ab?; *N 22978* (s)

Ebenaceae

Diospyros virginiana L., American persimmon; DA, UF; ab?; *N 22930* (s)

Elaeagnaceae

**Elaeagnus pungens* Thunb., Thorny-olive; [CAT 2]; UF; ab?; *G s.n.* [262141] (s)

Ericaceae

Lyonia lucida (Lam.) K. Koch, Shining fetterbush; FP; o; *G s.n.* [262176]

Rhododendron canescens (Michx.) Sweet, Piedmont azalea; UF; ab?; *N 23692*

Vaccinium arboreum Marshall, Sparkleberry; hab?; ab?; *G s.n.* [262232]

Vaccinium corymbosum L., Smooth highbush blueberry; DA; ab?; *G s.n.* [262233] (s)

Euphorbiaceae

Acalypha rhomboidea Raf., Rhombic copperleaf; DA; i; *N 24413*

Cnidoscolus stimulosus (Michx.) Engelm. & A. Gray, Spurge-nettle; DA; i; *N 23041*

**Croton capitatus* Michx., Woolly croton; DA; ab?; *N 24408*

Euphorbia cyathophora Murr., Painted leaf; DA; i; *Z 2379*

Euphorbia hyssopifolia L. [*Chamaesyce hyssopifolia* (L.) Small], Hyssopleaf sandmat; hab?; i; *S 4052*

**Triadica sebifera* (L.) Small, Chinese tallow-tree; [CAT 1]; FP, PM; i-c; *N 22965* (s), *24376*; *Z 2103*

Fabaceae

**Albizia julibrissin* Durazz., Silktree; [CAT 1]; DA, UF; ab?; *N 22952*

Centrosema virginianum (L.) Benth., Spurred butterfly-pea; DA; i; *Z 2371*

Cercis canadensis L. var. *canadensis*, Eastern redbud; DA/UF; o-c; *N 22926*; *Z 2360*

Chamaecrista nictitans (L.) Moench var. *nictitans*, Common sensitive-plant; DA; ab?; *G s.n.* [262124]
Desmodium ciliare (Muhl. ex Willd.) DC., Hairy small-leaf ticktrefoil; DA; i; *G s.n.* [262134]
Desmodium paniculatum (L.) DC. var. *paniculatum*, Panicled ticktrefoil; DA; ab?; *G s.n.* [262135]
Galactia volubilis (L.) Britton var. *volubilis*, Eastern milkpea; DA; o; *Z 2276*
**Lespedeza cuneata* G. Don, Sericea lespedeza; [CAT 1]; DA; c; *G s.n.* [262161]; *Z 2383*
Lespedeza stuevei Nutt., Velvety lespedeza; DA; o; *Z 2373*
**Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maes. & Alm., Kudzu; [CAT 1]; DA; c; *N 24392*
**Senna obtusifolia* (L.) Irwin & Barneby, Sicklepod; DA; o; *Z 2375*
**Sesbania punicea* Benth., Rattlebox; [CAT 2]; PM; o; *Z 2284*
Sesbania vesicaria (Jacqu.) Elliott [*Glottidium vesicarium* (Jacq.) R.M. Harper], Bladderpod; FP; c; *N 24369*
Tephrosia spicata (L.) Pers., Spiked hoarypea; DA; i; *N 23027*
**Trifolium arvense* L., Rabbitfoot clover; DA; c; *Z 2113*
**Trifolium dubium* Sibth., Low hop clover; DA; i; *N 23618, 23626; S 3066*
**Vicia hirsuta* (L.) S.F. Gray, Tiny vetch; DA; ab?, *N 23713*
**Vicia lathyroides* L., Spring vetch; DA; ab?; *N 23620*
**Vicia sativa* (L.) Ehret ssp. *nigra* (L.) Ehrh., Narrowleaf vetch; DA; ab?; *N 23631; S 3044*
**Vicia tetrasperma* (L.) Scherb., Slender vetch; DA; ab?; *N 23665*
**Wisteria sinensis* (Sims) DC., Chinese wisteria; [CAT 1]; DA; ab?; *G s.n.* [262242]

Fagaceae
Castanea pumila (L.) Mill., Common chinquapin; UF; ab?; *N 24378* (s)
Fagus grandifolia Ehrh., American beech; UF; i; *N 23687*
Quercus coccinea Wangenh., Scarlet oak; LM: DA, FP; i; *Z 2265*
Quercus falcata Michx., Spanish oak; UF; ab?; *G s.n.* [262207]
Quercus laurifolia Michx., Laurel oak; FP; ab?; *G s.n.* [262208] (s)
Quercus lyrata L., Overcup oak; FP; ab?; *G s.n.* [262209] (s)
Quercus michauxii Nutt., Basket oak; DA; ab?; *S 3075*
Quercus nigra L., Water oak; FP, UF; LM: DA, FP; o; *G s.n.* [262210]; *Z 2266, 2285* (s), *2287* (s)
Quercus phellos L., Willow oak; UF; ab?; *S 4127* (s)
Quercus shumardii Buckley, Shumard oak; UF; ab?; *G s.n.* [262211]
Quercus velutina Lam., Black oak; UF; LM: DA, FP; i; *N 23040* (s); *Z 2262*

Gelsemiaceae
Gelsemium sempervirens (L.) St.-Hil., Carolina jessamine; UF; ab?; *G s.n.* [262149]

Geraniaceae
Geranium carolinianum L., Carolina crane's-bill; DA; i; *N 23624*
**Geranium molle* L., Dove's-foot crane's-bill; DA; ab?; *N 23678*

Haloragaceae
**Myriophyllum aquaticum* (Vell.) Verdc., Parrot-feather; [CAT 2]; PM; i-c; *N 22948* (s), *24411*(s); *Z 2115* (s)

Hamamelidaceae
Hamamelis virginiana L., Witch-hazel; UF; i; *N 23689* (s)

Hydrangeaceae
Hydrangea quercifolia Bartram, Oakleaf hydrangea; UF; ab?; *G s.n.* [262151]; *N 23693* (s)

Hydrocharitaceae
**Najas minor* All., Spinyleaf naiad; PM; c?; *N 22949* (s)

Hydroleaceae
Hydrolea quadrivalvis Walter, Waterpod; PM; ab?; *N 22981*

Hypericaceae
Hypericum gentianoides (L.) Britton, Sterns & Poggenb., Pineweed; DA; o; *N 24397*
Hypericum hypericoides (L.) Krantz, St. Andrew's cross; UF; ab?; *G s.n.* [262152]
Hypericum mutilum L., Dwarf St.-John's-wort; DA; i; LM: DA, FP; i; *N 23002; Z 2250*
Hypericum walteri J.F. Gmel. [*Triadenum walteri* (J.F. Gmel.) Gleason], Walter's marsh St.-John's-wort; PM; o; *N 22984* (s)

Iridaceae
Iris hexagona Walter, Anglepod blue flag; PM; i; *N 23698; Z 2102*
Sisyrinchium atlanticum E.P. Bicknell, Atlantic blue-eyed grass; UF; ab?; *S 4164*

Iteaceae
Itea virginica L., Virginia-willow; FP; o; *G s.n.* [262156]

Juglandaceae
Carya cordiformis (Wang.) K. Koch, Bitternut hickory; UF; i; *N 23058* (s)
Carya glabra (Mill.) Sweet, Pignut hickory; UF; ab?; *G s.n.* [262121]
**Carya illinoinensis* (Wangenh.) K. Koch, Pecan; DA; ab?; *N 22989*
Carya ovata (Mill.) K. Koch, Common shagbark hickory; UF; o-c; *Z 2292* (s), *2399*
Carya pallida (Ashe) Engl. & Graebn., Sand hickory; UF; ab?; *S 3092*
Carya tomentosa (Lam. ex Poir.) Nutt. ex Elliott [*C. alba* (L.) Nutt.], Mockernut hickory; UF; ab?; *G s.n.* [262120] (s)

Juncaceae
Juncus coriaceus Mack., Leathery rush; FP; ab?; *G s.n.* [262157]
Juncus dichotomus Elliott, Forked rush; PM, UF; i-o; *G s.n.* [262158], [262159]
Luzula bulbosa (Alph. Wood) Smyth & L.C.R. Smyth, Bulbous wood-sedge; DA; i; *N 23647*
Luzula echinata (Small) F.J. Hermann, Spreading wood-rush; UF; i-o; *G s.n.* [262174]; *N 23688*

Lamiaceae
Callicarpa americana L., Beautyberry; UF; i; *N 23023*
**Lamium amplexicaule* L., Henbit; DA; o; *N 23643*
**Lamium purpureum* L., Purple dead-nettle; DA; ab?; *N 23652*
Lycopus rubellus Moench., Stalked bugleweed; DA, FP; r-i; *N 23034* (s); *24366*
Monarda punctata L., Eastern horse-mint; DA; ab?; *N 24406*
**Perilla frutescens* (L.) Britton, Beefsteak plant; LM: DA; c; *Z 2386*
Salvia lyrata L, Lyreleaf sage; DA; ab?; *N 23659*
Scutellaria lateriflora L., Mad dog skullcap; FP; i; *N 24373* (s)
**Stachys floridana* Shuttlw. ex Benth., Florida betony; [CAT 3]; DA; c; *N 24394* (s)
Trichostema dichotomum L., Common blue curls; DA, UF; ab?; *G s.n.* [262227]

Lauraceae
Lindera benzoin (L.) Blume, Northern spicebush; hab?; i; *G s.n.* [262164]
Persea palustris (Raf.) Sargent, Swamp bay; FP; i; *N 23020*
Sassafras albidum (Nutt.) Nees, Sassafras; DA, UF; i; *N 23031* (s); *Z 2361* (s)

Liliaceae
Erythronium umbilicatum Parks & Hardin, Trout lily; UF; i; *N 23685*

Linderniaceae
Lindernia dubia (L.) Pennell var. *dubia*, Moistbank false pimpernel; FP, PM; c; *G s.n.* [262165]; *N 24374*

Magnoliaceae
Liriodendron tulipifera L., Tulip-tree; UF; o; *N 23013* (s); *S 4156*
Magnolia grandiflora L., Southern magnolia; UF; r; *N 23049* (s)

Magnolia virginiana L., Sweet bay; DA; i; *N 23029* (s)

Malvaceae

Hibiscus laevis All., Smooth rose-mallow; PM; i-o; *N 22973, 24414; Z 2116*

Modiola caroliniana (L.) G. Don, Bristly-mallow; DA; ab?; *N 24410*

**Sida rhombifolia* L., Arrowleaf sida; DA; ab?; *G s.n.* [262220]

Melanthiaceae

Trillium maculatum Raf., Mottled trillium; PM?; ab?; *S 3047*

Meliaceae

**Melia azedarach* L., Chinaberry; [CAT 1]; DA; ab?; *G s.n.* [262178]

Menispermaceae

Calycocarpum lyonii (Pursh) A. Gray, Cupseed; PM; ab?; *G s.n.* [262106]

Cocculus carolinus (L.) DC., Coralbeeds; DA; o; *N 22959; Z 2099* (s)

Menispermum canadense L., Moonseed; DA, PM; ab?; *G s.n.* [262179] (s)

Moraceae

**Morus alba* L., White mulberry; [CAT 3]; DA; r-c; *N 23037* (s), *23676; Z 2125*

Morus rubra L., Red mulberry; UF; LM: DA, FP; i-o; *G s.n.* [262181] (s); *N 22939* (s); *Z 2261* (s)

Myricaceae

Morella cerifera (L.) Small, Common wax-myrtle; DA; ab?; *S 4113*

Nyctaginaceae

**Mirabilis jalapa* L., Garden four-o'clock; DA; o; *Z 2377*

Oleaceae

Forestiera acuminata (Michx.) Poir., Swamp privet; PM; o; *N 22972* (s)

Fraxinus caroliniana Mill., Water ash; FP; i; *N 22985* (s)

Fraxinus pennsylvanica Marshall, Green ash; FP; ab?; *N 22940* (s)

**Ligustrum japonicum* Thunb., Japanese privet; [CAT 2]; DA; o; *N 23046*

**Ligustrum sinense* Lour., Chinese privet; [CAT 1]; FP, UF; c; *N 23012; Z 2283*

Onagraceae

Ludwigia decurrens Walter, Wingstem water-primrose; PM; o; *G s.n.* [262169; specimen comprises detached infructescences], [262170]

Ludwigia glandulosa Wahl., Small-flowered seedbox; PM; o; *N 22950*

Ludwigia leptocarpa (Nutt.) Hara, Water-willow; FP; ab?; *G s.n.* [262171]

Ludwigia palustris (L.) Elliott, Common water-purslane; DA; ab?; *N 23001*

Ludwigia peploides Kunth var. *glabrescens* (Kuntze) Shinners, Floating primrosewillow; PM; r; *G s.n.* [262172]; *Z 2120*

Ludwigia repens J.R. Forst., Creeping seedbox; hab?; ab?; *G s.n.* [262173]

Oenothera laciniata L., Cutleaf evening-primrose; DA; ab?; *G s.n.* [262187]

Orchidaceae

Tipularia discolor (Pursh) Nutt., Cranefly orchid; UF; r; *N 23700* (s)

Orobanchaceae

Agalinis fasciculata Raf., Beach false foxglove; DA; i-c; *N 24401, 24407; S 4114; Z 2374*

Oxalidaceae

Oxalis dillenii Jacq., Southern yellow wood-sorrel; DA; i; *N 23066; 23625; S 3065*

**Oxalis articulata* Savigny in Lam. [*O. rubra* A. St.-Hil.], Windowbox wood-sorrel; DA; o; *Z 2134*

Passifloraceae

Passiflora incarnata L., Maypops; DA; o; *N 22957*

Passiflora lutea L. var. *lutea*, Eastern yellow passionflower; UF; ab?; *N 22938* (s)

Phyrmaceae

Mimulus alatus Aiton, Winged monkey-flower; PM; LM: DA, FP; o; *N 22977; Z 2274*

Plantaginaceae

Callitriche heterophylla Pursh var. *heterophylla*, Common water-starwort; LM: PM, ab?; *S 4145*

Nuttallanthus canadensis (L.) D.A. Sutton, Common toadflax; DA; i; *G s.n.* [262184]; *N 23648*

**Plantago aristata* Michx., Buckthorn plantain; DA; o; *Z 2132a*

**Plantago lanceolata* L., English plantain; DA; o; *Z 2133*

Plantago rugellii Desc., American plantain; LM: DA; o; *Z 2268*

Plantago wrightiana Desc., Wright's plantain; DA; o; *Z 2132b*

**Veronica arvensis* L., Corn speedwell; DA; ab?; *N 23619; S 3037*

Platanaceae

Platanus occidentalis J.F. Gmel., Sycamore; PM, UF; i-c; *G s.n.* [262200]; *Z 2289*

Poaceae

Andropogon glomeratus (Walter) Britton, Bushy bluestem; DA; o; *Z 2364*

Andropogon ternarius Michx. var. *ternarius*, Splitbeard bluestem; DA; o; *Z 2372*

Aristida purpurascens Poir. Arrowfeather; DA; i-c; *N 24379, 24398*

Arundinaria gigantea (Walter) Muhl., Giant cane; DA; o; *N 23010* (s); *Z 2107* (s)

Axonopus compressus (Sw.) Beav., Southern carpet grass; PM; ab?; *N 22964*

**Briza minor* L., Lesser quaking grass; DA; o; *N 23644*

**Bromus catharticus* Vahl var. *catharticus*, Rescue grass; DA; o-c; *N 23628*

**Bromus commutatus* Schrad., Hairy Chess; DA; c; *N 22988*

Chasmanthium latifolium (Michx.) Yates, River oats; UF; c; *N 22936*

Chasmanthium laxum (L.) Yates, Slender spikegrass; DA; i; *N 23028*

**Cynodon dactylon* (L.) Pers. var. *dactylon*, Bermuda grass; [CAT 2]; DA; c; *Z 2112*

**Dactylis glomerata* L., Orchard grass; DA; c; *Z 2094*

Danthonia spicata (L.) Beauv., Poverty oatgrass; DA; o; *N 23035*

Dichanthelium aciculare (Desv. ex Poir.) Gould & C.A. Clark, Witch grass; DA; o; *N 22995*

Dichanthelium dichotomum (L.) Gould var. *dichotomum*, Cypress witch grass; DA; c; *N 23047*

Dichanthelium commutatum (Schult.) Gould var. *commutatum*, Variable witch grass; UF?; ab?; *S 4068*

Dichanthelium scoparium (Lam.) Gould, Velvet witch grass; DA; ab?; *N 23000*

Digitaria ciliaris (Retz.) Koeler, Southern crab grass; DA; ab?; *G s.n.* [262137]

**Digitaria sanguinalis* (L.) Scop., Northern crab grass; DA; c; *N 24384*

Digitaria serotina (Walter) Michx., Dwarf crab grass; DA; o; *G s.n.* [262138]

**Echinochloa crusgalli* (L.) Beauv. var. *crusgalli*, Barnyard-grass; DA, FP; i-c; *N 24370, 24391*

Elymus virginicus L. var. *virginicus*, Common eastern wild-rye; PM; i; *N 22980, G s.n.* [262143]

**Eragrostis cilianensis* (All.) Vignolo ex Janch., Stinkgrass; DA; ab?; *G s.n.* [262144]

**Eragrostis curvula* Nees, Weeping lovegrass; [CAT 3]; DA; c; *N 24386*

Eragrostis spectabilis (Pursh) Steudel, Purple lovegrass; DA. FP; i; *G s.n.* [262145]; *N 24382; S 4060*

Festuca subverticillata (Pers.) Alexeev, Nodding fescue; DA; c; *Z 2108*

Leersia lenticularis Michx., Catchfly cutgrass; LM: FP; i; *Z 2388*

Leersia oryzoides (L.) Sw., Rice cutgrass; FP, PM; i; *G s.n.* [262162], [262163]; *N 22974; Z 2382*

Leersia virginica Willd., White cutgrass; PM; o; *N 22944*

**Lolium perenne* L. var. *aristatum* Willd., Italian ryegrass; hab?; ab?; *G s.n.* [262168]
Melica mutica Walter, Two-flower melic; DA, UF; i; *N 23674*
Oplismenus hirtellus (Lam.) Roem. & Schult., Woods-grass; DA, FP, UF; c; *G s.n.* [262189]; *N 22933, 24363*
Panicum anceps Michx., Beaked panicum; DA, FP, PM; o; *N 22963; Z 2367*
Panicum rigidulum Bosc ex Nees, Redtop panicum; PM; o; *N 22947*
Panicum virgatum L., Switchgrass; DA, UF; ab?; *G s.n.* [262193]
**Paspalum dilatatum* Poir. ssp. *dilatatum*, Dallis grass; DA; c; *G s.n.* [262194]; *Z 2105*
Paspalum floridanum Michx., Florida paspalum; DA; o; *Z 2363*
**Paspalum notatum* Flügge var. *saurae* Parodi, Bahia grass; [CAT 2]; DA; o; *N 22955*
**Paspalum urvillei* Steud., Vasey grass; [CAT 3]; DA; o; *N 22954*
Phanopyrum gymnocarpon (Elliott) Nash, Swamp phanopyrum; FP, PM; o-c; *G s.n.* [262197], [262198]; *Z 2381*
**Phyllostachys aurea* Carrière ex Rivière & C. Rivière, Golden bamboo; [CAT 2]; DA; c; *N 24400* (s)
Piptochaetium avenaceum (L.) Parodi, Eastern needlegrass; DA; o-c; *N 23657; Z 2397*
**Poa annua* L., Annual bluegrass; [CAT 3]; DA; o; *N 23637*
Poa autumnalis Muhl., Autumn bluegrass; PM; i; *G s.n.* [262201]
**Poa compressa* L., Canada bluegrass; DA; i; *N 23630*
Saccharum giganteum (Walter) Pers., Sugarcane plume grass; DA; ab?, *G s.n.* [262217]
**Schedonorus arundinaceus* (Schreb.) Dumort., Tall fescue; [CAT 3]; DA; i-c; *N 23651, 24393*
Setaria parviflora (Poir.) Kerguelen, Knotroot bristlegrass; DA; i; *G s.n.* [262219]; *Z 2368*
Sorghastrum nutans (L.) Nash, Yellow Indiangrass; DA; o; *Z 2366*
**Sorghum bicolor* (L.) Moench.; DA; i; *N 24383*
**Sorghum halepense* (L.) Pers., Johnson grass; [CAT 3]; DA; o; *N 22986*
Tridens flavus (L.) Hitchc., Redtop; DA; ab?; *G s.n.* [262228]
**Vulpia myuros* (L.) Gmel., Rat-tail fescue; DA; c; *N 23677*

Polygonaceae

Brunnichia ovata (Walter) Shinners, Buckwheat-vine; PM; o-c; *N 22961, 22983; Z 2123* (s), *2282*
Persicaria hydropiperoides (Michx.) Small [*Polygonum hydropiperoides* Michx.], Swamp smartweed; PM; c; *Z 2118*
**Persicaria longiseta* (Bruijin) Kitag. [*Polygonum cespitosum* var. *longisetum* Bruijin], Longbristle smartweed; [CAT 4]; LM: DA, FP; c; *Z 2249*
Persicaria sagittata (L.) Fross ex Nakai [*Polygonum sagittatum* L.], Arrowleaf tearthumb; FP; ab?; *G s.n.* [262204]
Persicaria virginiana (L.) Gaertn. [*Polygonum virginianum* L.], Jumpseed; PM, UF; i-o; LM: DA, FP; i; *G s.n.* [262205]; *N 23024; Z 2255*
**Rumex acetosella* L., Red dock; DA; ab?; *G s.n.* [262215]
**Rumex crispus* L., Curly dock; PM; ab?; *G s.n.* [262216]
Rumex hastatulus Baldwin, Wild dock; DA; c; *Z 2135*

Ranunculaceae

Ranunculus abortivus L., Kidneyleaf buttercup; DA; i; *N 23708; S 3051*

Rhamnaceae

Berchemia scandens (Hill.) K. Koch, Supplejack; DA, FP, PM; i-o; *G s.n.* [262101]; *N 22971; Z 2128* (s)

Rosaceae

Agrimonia pubescens Wallr., Downy agrimony; LM: DA, FP; o; *Z 2267*
**Aphanes australis* Rydb. [*A. microcarpa* (Boiss. & Reut.) Rothm.], Parsley-piert; DA; o; *N 23635*
Crataegus aprica Beadle, Sunny hawthorn; DA; o; *N 23681*
Crataegus dispar Beadle, Aiken hawthorn; UF; r; *N 23658*
Crataegus marshallii Eggl., Parsley haw; DA; ab?; *G s.n.* [262128] (s)
Crataegus spathulata Michx., Littlehip hawthorn; DA, UF; o; *N 22928* (s), *22996* (s)
Crataegus uniflora Muenchh., Oneflower hawthorn; UF; ab?; *G s.n.* [262129] (s)
Crataegus viridis L., Green hawthorn; UF; LM: DA, FP; i: *N 22946* (s); *Z 2264* (s)
Malus angustifolia (Aiton) Michx., Wild crabapple; DA, UF; ab?; *G s.n.* [262177] (s); *N 23003*
**Potentilla indica* (Andr.) T. Wolf [*Duchesnea indica* (Andrews) Focke], Indian-strawberry; DA; ab?; *G s.n.* [262140]; *S 3029*
Prunus angustifolia Marshall var. *angustifolia*, Chickasaw plum; DA; ab?; *S 4171*
Prunus caroliniana (Mill.) Aiton, Carolina laurel cherry; DA, UF; c; *N 22931; Z 2091*
Prunus serotina Ehrh. var. *serotina*, Black cherry; DA, UF; o; *G s.n.* [262206]; *Z 2124*
**Pyracantha koidzumii* (Hayata) Rehder, Formosan firethorn; CULT; *Z 2359*
Rubus pensilvanicus Poir. [*R. argutus* Link], Pennsylvania blackberry; DA, PM; ab?; *G s.n.* [262214]; *N 23710*
Rubus trivialis Michx., Southern dewberry; DA; c; *N 23670*
**Spiraea cantoniensis* Lour., Reeve's meadowsweet; UF?/CULT?; ab?; *G s.n.* [262223] [Plants persisting from cultivation?]
**Spiraea thunbergii* Siebold ex Blume, Thunberg's meadowsweet; UF?/CULT?; ab?; *G s.n.* [262224] [Plants persisting from cultivation?]

Rubiaceae

Cephalanthus occidentalis L., Buttonbush; PM; o; G s.n. [262123]; *N 22982*
Diodia teres Walter, Poorjoe; DA; o; *G s.n.* [262139]; *N 29113*
Diodia virginiana L., Virginia buttonweed; DA; ab?; *N 23006*
Galium aparine L., Cleavers; DA; o; *N 22667*
**Galium sherardia* E.H.L. Krause, [*Sherardia arvensis* L.], Field-madder; DA; o; *N 23645*
Galium triflorum Michx., Sweet-scented bedstraw; PM; r; *Z 2119*
Houstonia pusilla Schoepf, Tiny bluet; DA; c; *N 23641*
Mitchella repens L., Partridge-berry; UF; ab?; *G s.n.* [262180] (s)
**Richardia brasiliensis* Gomes, Tropical Mexican-clover; DA?; ab?; *S 4058*

Rutaceae

Ptelea trifoliata L., Hop-tree; UF; o; *Z 2288* (s)

Santalaceae

Phoradendron serotinum (Raf.) M. C. Johnst. ssp. *serotinum*, American mistletoe; DA; o; *Z 2398*

Sapindaceae

Acer floridanum (Chapm.) Pax [*A. barbatum* Michx.], Southern sugar maple; UF; i; *N 23062* (s)
Acer negundo L., Box elder; FP, UF; o; *N 23068; 23695* (s)
Acer rubrum L., Red maple; UF; o; *N 22942* (s)
Acer saccharinum L., Silver maple; UF; ab?; *N 22935* (s)
Aesculus pavia L. var. *pavia*, Red buckeye; FP, UF; ab?; *N 23005, 23683*
Aesculus sylvatica R. Bartram, Painted buckeye; UF; ab?; *N 23705*
**Koelreuteria paniculata* Laxm., Golden rain tree; DA; i; *N 24405; Z 2092*

Sapotaceae

Sideroxylon lanuginosum L., Gum bumelia; UF; r-i; *N 23050* (s), *23656*
Sideroxylon lycioides L., Buckthorn bumelia; DA, PM; r-i; *N 22966* (s); *Z 2114* (s)

Saururaceae

Saururus cernuus L., Lizard's-tail; PM, i; LM: DA, FP; o; *N 23018; Z 2254*

Scrophulariaceae

**Verbascum thapsus* L., Woolly mullein; [CAT 4]; DA; r; *Z 2362*

Simaroubaceae
**Ailanthus altissima* (Mill.) Swingle, Tree-of-heaven; [CAT 1]; DA; o; *N 23036* (s)

Smilacaceae
Smilax bona-nox L., Catbrier; DA, PM; o-c; *N 22929; 23069; Z 2097*
Smilax glauca Walter, Whiteleaf greenbrier; PM; c; *Z 2281* (s)
Smilax hispida Raf. [*S. tamnoides* L.], Bristly greenbrier; DA; ab?; *G s.n.* [262221]
Smilax laurifolia L., Bamboo vine; LM: DA, FP; o; *Z 2258*
Smilax rotundifolia L., Common greenbrier; LM: DA, FP; o; *Z 2260* (s)
Smilax smallii Morong, Jackson-brier; UF; o; *G s.n.* [262222]; *N 23057* (s)

Solanaceae
**Salpichroa origanifolia* Thell., Lily-of-the-valley vine; DA; o; *H s.n.*

Styracaceae
Halesia carolina L., Little silverbell; UF; i; *N 23022; 23061*
Halesia tetraptera J. Ellis, Common silverbell; UF; ab?; *N 23706*

Symplocaceae
Symplocos tinctoria (L.) L'Hér., Sweetleaf; UF; i; *N 23690*

Tetrachondraceae
Polypremum procumbens L., Rustweed; DA; c; *N 22958*

Typhaceae
Typha latifolia L., Common cattail; FP, PM; i; *Z 2104*

Ulmaceae
Planera aquatica Walter ex J. F. Gmel.; Planer-tree; FP; i; *N 23067* (s)
Ulmus alata Michx., Winged elm; FP, UF; i; *G s.n.* [262229]; *N 22937* (s)
Ulmus americana L., American elm; UF; LM: DA, FP; i-c; *G s.n.* [262230]; *Z 2106* (s); *2263* (s), *2396* (s)
Ulmus rubra Muhl., Slippery elm; FP; o; *G s.n.* [262231] (s); *N 22941* (s)

Urticaceae
Boehmeria cylindrica (L.) Sw., False-nettle; DA; i; *N 23017*
Laportea canadensis (L.) Wedd., Wood-nettle; LM: DA, FP; o; *Z 2390*
Pilea pumila (L.) A. Gray, Greenfruit clearweed; FP; o; *N 24368*

Verbenaceae
**Glandularia pulchella* (Sweet) Tronc., Moss vervain; DA; o-c; *G s.n.* [262150]; *N 24404*
**Verbena bonariensis* L., Purpletop vervain; [CAT 4]; DA; ab?; *N 22991*
**Verbena rigida* Spreng., Tuberous vervain; DA; o; *N 22956; 24396; Z 2111*

Violaceae
**Viola arvensis* Murray, European field-pansy; DA; o; *N 23627*
Viola bicolor Pursh, Wild pansy; DA; ab?; *G s.n.* [262237]; *N 23714*
Viola primulifolia Willd., Primrose-leaf violet; DA; ab?; *G s.n.* [262238] (s)
Viola sororia Willd. [*V. affinis* Leconte], Common blue violet; DA, UF; i-o; *G s.n.* [262239]; *N 23638; S 3056*

Vitaceae
Ampelopsis arborea (L.) Koehne, Peppervine; DA; ab?; *N 22993*
Vitis aestivalis Michx. var. *bicolor* Deam, Silverleaf grape; FP, PM; ab?; *G s.n.* [262240]
Vitis cinerea (Engelm.) Millard var. *floridana* Munson, Florida grape; DA; o; *N 23043; Z 2126*
Vitis rotundifolia Michx., Muscadine; DA, UF; c; *N 23039* (s); *Z 2109*
Vitis vulpina L., Frost grape; DA, UF; o-c; *N 23045; Z 2098* (s)

APPENDIX 1
VASCULAR PLANTS REPORTED FROM OCMULGEE NATIONAL MONUMENT

The following 189 unvouchered vascular plant species have been cited for Ocmulgee National Monument in various NPS reports and databases (Froeschauer 1989; Puckett 1997; Burkholder et al. 2010; NPS 2012c). Where applicable, the name on the original lists (in brackets) follows the current accepted synonym. Although many of these taxa may presently occur (or may have occurred) within park boundaries, a significant percentage of these names likely represent misidentifications of species listed in the "Annotated List" of vouchered specimens.

Amaranthaceae: *Amaranthus hybridus* L.
Apiaceae: *Ptilimnium capillaceum* (Michx.) Raf.; *Sanicula marilandica* L.
Apocynaceae: *Amsonia tabernaemontana* Walter; *Apocynum cannabinum* L.; *Asclepias tuberosa* Elliott; *Matelea obliqua* (Jacq.) Woods. [*M. carolinensis* (Jacq.) Woods.]
Araceae: *Lemna perpusilla* Torr.; *Spirodela polyrhiza* (L.) Schleid.
Aristolochiaceae: *Asarum canadense* L.
Asparagaceae: *Liriope muscari* Bailey; *Ornithogalum umbellatum* L.; *Maianthemum racemosum* (L.) Link [*Smilacina racemosa* (L.) Desf.]; *Yucca flaccida* Haw.
Asteraceae: *Ampelaster carolinianus* (Walter) Nesom [*Aster carolinianus* Walter]; *Baccharis halimifolia* L.; *Balduina angustifolia* (Pursh) B.L. Rob.; *Bidens aristosa* (Michx.) Britton; *Chrysogonum virginianum* L.; *Chrysopsis mariana* (L.) Elliott [*Heterotheca mariana* (L.) Shinners]; *Elephantopus tomentosus* L.; *Erigeron annuus* (L.) Pers.; *E. quercifolius* Lam.; *E. strigosus* Muhl. ex Willd. var. *calcicola* J.R. Allison; *Eupatorium capillifolium* L.; *Helianthus angustifolius* L.; *H. annuus* L.; *H.* strumosus L.; *Heterotheca subaxillaris* (Lam.) Britton & Rusby; *Krigia cespitosa* (Raf.) K.L. Chambers; *K. dandelion* (L.) Nutt.; *Packera anonyma* L. [*Senecio smallii* Britton]; *Pluchea camphorata* (L.) DC.; *Pseudognaphalium obtusifolium* L. var. *obtusifolium* [*Gnaphalium obtusifolium* L.]; *Pyrrhopappus carolinianus* (Willd.) Ohwi; *Rudbeckia hirta* L.; *Solidago canadensis* L. var. *scabra* (Muhl. ex Willd.) Torr. & A. Gray; *S. chapmanii* A. Gray [*S. odora* Aiton]; *S. erecta* Pursh; *S. gigantea* Aiton; *Symphyotrichum puniceum* (L.) Á. Löve & D. Löve var. *puniceum*; *Taraxacum officinale* L.; *Verbesina alternifolia* (L.) Britton ex Kearney [*Actinomeris alternifolia* DC.]; *Vernonia acaulis* (Walter) Gleason; *V. angustifolia* Michx.; *V. flaccidifolius* Small; *V. noveboracensis* L.
Balsaminaceae: *Impatiens capensis* Meerb.
Betulaceae: *Alnus serrulata* (Aiton) Willd.
Blechnaceae: *Woodwardia virginica* (L.) Sm.
Boraginaceae: *Myosotis verna* Nutt.; *Phacelia maculata* Wood
Cactaceae: *Opuntia ficus-indica* (L.) Mill.
Campanulaceae: *Triodanis perfoliata* (L.) Nieuwl.
Cannabaceae: *Celtis occidentalis* L.
Commelinaceae: *Commelina communis* L.; *Tradescantia virginiana* L.
Convolvulaceae: *Calystegia spithamaea* (L.) Pursh; *C. sepium* (L.) R. Br. [*Convolvulus sepium* L.]; *Ipomoea lacunosa* L.; *I. nil* (L.) Roth
Cornaceae: *Nyssa sylvatica* Marshall
Cyperaceae: *Carex atlantica* L.H. Bailey; *C. gigantea* Rudge; *C. intumescens* Rudge; *C. nigromarginata* Schwein.; *C. scoparia* Schkuhr ex Willd.; *C. styloflexa* Buckley; *C. venusta* Dewey
Dioscoreaceae: *Dioscorea floridana* Bartlett

Elaeagnaceae: *Elaeagnus commutata* Bernh.
Equisetaceae: *Equisetum hyemale* L.
Ericaceae: *Chimaphila maculata* (L.) Pursh; *Monotropa uniflora* L.; *Vaccinium stamineum* L.

Euphorbiaceae: *Acalypha gracilens* A. Gray; *Euphorbia maculata* L. [*Chamaesyce maculata* (L.) Small]
Fabaceae: *Amorpha fruticosa* L.; *Chamaecrista fasciculata* (Michx.) Greene; *Clitoria mariana* L.; *Desmodium perplexum* B.G. Schub.; *Erythrina herbacea* L.; *Hylodesmum nudiflorum* (L.) H. Ohashi & R.R. Mill [*Desmodium nudiflorum* (L.) DC.]; *Lespedeza capitata* Michx.; *L. repens* (L.) W.P.C. Barton; *Mimosa microphylla* Dryand. ex Sm. [*Schrankia microphylla* (Dryand.) J.F. Macbr.]; *Senna occidentalis* (L.) Link [*Cassia occidentalis* L.]; *Strophostyles helvula* (L.) Elliott; *Tephrosia virginiana* (L.) Pers.; *Trifolium incarnatum* L.; *Wisteria frutescens* (L.) Poir.
Fagaceae: *Quercus alba* L.; *Q. pagoda* Raf.; *Q. stellata* Wangenh.
Geraniaceae: *Geranium maculatum* L.
Hydrocharitaceae: *Najas filifolia* Haynes
Hypoxidaceae: *Hypoxis hirsuta* (L.) Coville
Iridaceae: *Iris cristata* Aiton; *Iris virginica* L.
Juglandaceae: *Carya aquatica* (Michx. f.) Nutt.; *C. ovalis* (Wangenh.) Sarg.; *Juglans nigra* L.
Juncaceae: *Juncus effusus* L.
Lamiaceae: *Prunella vulgaris* L.
Lentibulariaceae: *Utricularia inflata* Walter
Liliaceae: *Erythronium americanum* Ker Gawl.
Loganiaceae: *Spigelia mariliandica* (L.) L.
Malvaceae: *Sida spinosa* L.
Melanthiaceae: *Trillium cuneatum* Raf.; *T. decipiens* J.D. Freeman
Melastomataceae: *Rhexia virginica* L.
Moraceae: *Maclura pomifera* (Raf.) C.K. Schneid.
Onagraceae: *Ludwigia peruviana* (L.) H. Hara; *Oenothera biennis* L.; *O. fruticosa* L.; *O. speciosa* Nutt.
Ophioglossaceae: *Botrychium lunarioides* (Michx.) Sweet
Orchidaceae: *Goodyera pubescens* (Willd.) R. Br.
Orobanchaceae: *Agalinis obtusifolia* Raf.; *A. purpurea* (L.) Pennell; *Aureolaria virginica* (L.) Pennell
Osmundaceae: *Osmunda claytoniana* L.
Oxalidaceae: *Oxalis stricta* L.; *O. violacea* L.
Papaveraceae: *Sanguinaria canadensis* L.
Phytolaccaceae: *Phytolacca americana* L.; *P. rigida* Small
Phyrmaceae: *Mazus pumilus* (Burm. f.) Steenis
Pinaceae: *Cedrus deodara* Roxb. ex D. Don; *Pinus echinata* Mill.; *P. glabra* Walter; *P. palustris* P. Mill
Plantaginaceae: *Penstemon australis* Small
Poaceae: *Andropogon virginicus* L.; *Aristida spiciformis* Elliott; *Arundinaria tecta* (Walter) Muhl.; *Axonopus fissifolius* (Raddi) Kuhlm. [*A. affinis* Chase]; *Cenchrus echinatus* L.; *C. longispinus* (Hack.) Fernald [*C. pauciflorus* Benth.]; *C. tribuloides* L.; *Dichanthelium boscii* (Poir.) Gould & C.A. Clark; *D. oligosanthes* (Schult.) Gould var. *oligosanthes* [*Panicum scribnerianum* Nash]; *Digitaria filiformis* (L.) Köler; *Eleusine indica* (L.) Gaertn.; *Erianthus giganteus* (Walter) Muhl.; *Leptoloma cognatum* (Schultes) Chase; *Microstegium vimineum* (Trin.) A. Camus; *Pennisetum glaucum* (L.) R. Br.; *Phalaris arundinacea* L.; *Phragmites australis* (Cav.) Trin. ex Steud. [*P. communis* Trin.]; *Poa chapmaniana* Scribn.; *Schedonorus pratensis* (Huds.) P. Beauv. [*Lolium pratense* (Huds.) Darbysh.]; *Schizachyrium scoparium* (Michx.) Nash; *Setaria corrugata* (Elliott) Schult.; *S. glauca* (L.) Beauv.; *Sporobolus indicus* [L.] R. Br. [*S. poiretii* (Roem. & Schult.) Hitchc.]
Polygonaceae: *Persicaria hirsuta* (Walter) Small [*Polygonum hirsutum* Walter]; *P. lapathifolia* (L.) Gray [*Polygonum lapathifolium* L.]; *P. maculosa* Gray [*Polygonum persicaria* L.]; *P. punctata* (Elliott) Small [*Polygonum punctatum* Elliott]
Ranunculaceae: *Anemone berlandieri* Pritz.; *Aquilegia canadensis* L.; *Clematis virginiana* L.; *Ranunculus bulbosus* L.
Rhamnaceae: *Frangula caroliniana* (Walter) A. Gray [*Rhamnus caroliniana* Walter]
Rosaceae: *Crataegus punctata* Jacq.; *Fragaria virginiana* L.; *Potentilla canadensis* L.; *Rosa carolina* L.; *Rubus canadensis* L.; *R. hispidus* L.; *Spiraea ×arguta* Zabel
Rubiaceae: *Houstonia caerulea* L.; *H. tenuifolia* Nutt.; *Richardia scabra* L.
Salicaceae: *Populus deltoides* W. Bartram ex Marshall; *Salix nigra* Marshall
Sapindaceae: *Acer saccharum* Marshall
Sapotaceae: *Sideroxylon tenax* L.
Smilacaceae: *Smilax ecirrata* (Englem. ex Kunth) S. Watson; *S. herbacea* L.; *S. walteri* Pursh
Solanaceae: *Datura stramonium* L.; *Physalis heterophylla* Nees; *Solanum americanum* Mill.; *S. carolinense* L.
Verbenaceae: *Verbena brasiliensis* Vell.
Violaceae: *Viola tricolor* L.
Vitaceae: *Parthenocissus quinquefolia* (L.) Planch.

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JOURNAL NOTICE

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ABSTRACT

A total of 302 vascular plant species and nine non-vascular species were noted between 2005 and 2012 on 21 small herbaceous openings known as "Florida upland glades" on thin soil over calcareous outcrops in Jackson and Gadsden counties, Florida. While these openings are dominated by grasses found on many other calcareous glades and prairies in the Southeast (e.g., *Schizachyrium scoparium*, *Sporobolus vaginiflorus*, *Muhlenbergia capillaris*), they are also unique in being characterized by the dominance of a sedge, *Schoenus nigricans*, which is absent from such openings in other states. Two-hundred and eighty of the 302 vascular species noted are native and 14 are listed as endangered by the state of Florida. One moss new to Florida (*Pleurochaete luteola*) and one probable new taxon of *Coreopsis* are reported from these glades. Between 32 and 49 percent of the native vascular species on Florida upland glades are shared with calcareous glades and prairies to the north and west from Georgia to Texas. Only three of the smaller Florida upland glades are currently protected on public land. The seven remaining larger intact glades are urgently in need of protection, either by public acquisition or conservation easements.

RESUMEN

Se anotaron un total de 302 especies plantas vasculares y nueve especies de no-vasculares entre 2005 y 2012 en 21 pequeños claros herbáceos conocidos como "Florida upland glades" sobre suelos someros en afloramientos calcáreos en los condados de Jackson y Gadsden, Florida. Mientras que estos claros están dominados por gramíneas que se encuentran en muchos otros pastizales calcáreos del sureste (ej., *Schizachyrium scoparium*, *Sporobolus vaginiflorus*, *Muhlenbergia capillaris*), son también únicos por estar caracterizados por la dominancia de de la ciperácea, *Schoenus nigricans*, que está ausente en los claros d otros estados. Doscientas ochenta de las- 302 especies vasculares son nativas y 14 están listadas como amenazadas para el estado de Florida. Se citan un nuevo musgo para Florida (*Pleurochaete luteola*) y un probable nuevo taxon de *Coreopsis*. Entre el 32 y el 49 por ciento de las especies vasculares nativas de los "Florida upland glades" se comparten con praderas del norte y oeste desde Georgia hasta Texas. Solo tres de los más pequeños "Florida upland glades" están protegidos actualmente en suelos públicos. Los siete restantes más grandes intactos necesitan protección urgentemente ya sea por adquisición pública, o por decretos de conservación.

INTRODUCTION

Florida upland glades are small (0.03 to 0.8 ha), largely herbaceous openings in an otherwise forested landscape, occurring on thin soils over calcareous substrates in dissected terrain in Jackson and Gadsden counties (plus one just north of the border in Decatur County, Georgia). They form the southeastern outpost of a series of calcareous prairies and glades in the southeastern U.S., stretching from eastern Texas north to southern Ohio and east to Georgia (Fig. 1). These isolated prairies and glades surrounded by forest are dominated on the deeper soils by some of the same grasses as the Midwestern tallgrass prairies (*Schizachyrium scoparium*, *Andropogon gerardii*, *Sorghastrum nutans* and *Panicum virgatum*; Sims 1988). Areas of shallower soil over calcareous substrates are characterized by the annual grass, *Sporobolus vaginiflorus* (Ware 2002; Lawless et al. 2006). While Florida upland glades share none of the endemic species of these calcareous openings to the north and west, they do have many species in common with them, including some of the same dominant grasses

[1]We dedicate this paper to Steven W. Leonard, who in 1982 brought attention to new glades, new Florida species, and a rare plant community in Florida.

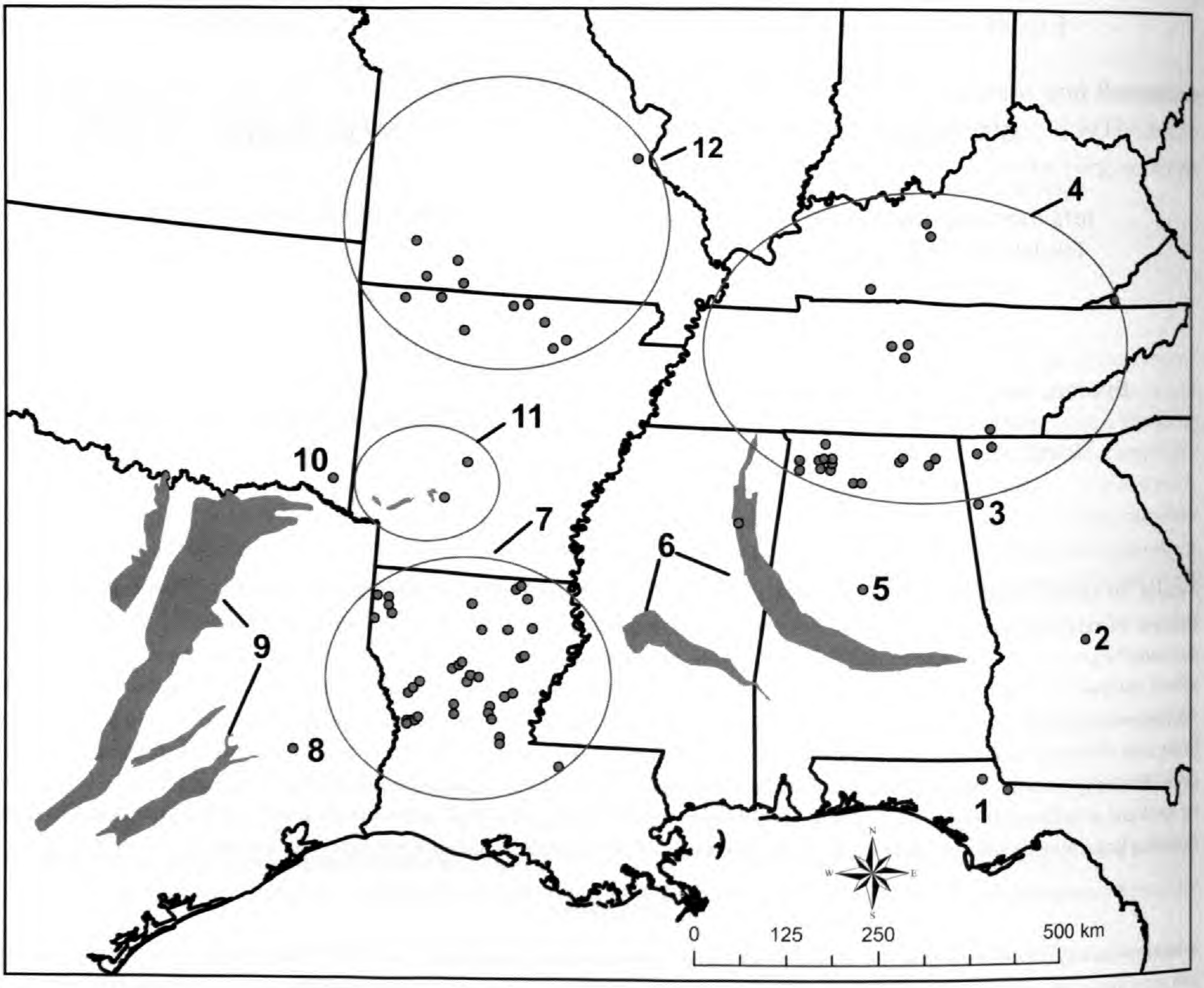


Fig. 1. Calcareous prairies and glades in the Southeastern U.S (map modified from Fig. 1.1 in Peacock & Schauwecker 2003). Filled polygons in MS, AL, and TX and points in LA represent the historical (vs. current) extent of blackland prairies in those areas. **1.** Florida Upland Glades. **2.** Oaky Woods Wildlife Management Area (Echols & Zomlefer 2010). **3.** Coosa Valley Prairies (Ware 2008; Natureserve 2012). **4.** Tennessee and related glades (Baskin & Baskin 2003). **5.** Ketona Dolomite Glades (Allison & Stevens 2001). **6.** Blackbelt Prairies of Mississippi and Alabama (Barone & Hill 2007; Schotz & Barbour 2009; Schotz 2011; Campbell & Seymour 2012). **7.** Louisiana Blackland Prairies (MacRoberts & MacRoberts 1995,1996; MacRoberts et al. 2003). **8.** Windham Prairie (Brown et al. 2002). **9.** Texas Blackland Prairies (Diamond & Smeins 1985). **10**. Weches Formation Glades (White & Arbour 2012). **11.** Blackland Prairies of Southwest Arkansas (Foti 1989; Zollner et al. 2003). **12.** Missouri and Arkansas Ozarks (Erickson et al. 1942; Kucera & Clark 1957; Nelson & Ladd 1980). (Not shown due to spatial limitations are xeric limestone prairies [Lawless et al. 2006], which are found in three areas: within circles 4 and 12 and just north of the KY border into extreme southern OH, IN, and IL.)

(*Schizachyrium scoparium*, *Muhlenbergia capillaris*, and *Sporobolus vaginiflorus*; Baskin and Baskin 2003). However, the Florida glades are also unique in having as one of their most characteristic dominants, the sedge *Schoenus nigricans*, which is not found at any of the other sites shown in Figure 1.

These graminoid-dominated openings on calcareous outcrops have traditionally been referred to as "glades" in Florida (or "upland glades" to distinguish them from the Florida Everglades). Baskin and Baskin (2000) and Lawless et al. (2004) suggest confining the term "limestone cedar glade" to sites dominated by annual C_4 grasses, cryptogams, and winter annuals, while using "xeric limestone prairies" and "barrens" to denote areas dominated by perennial grasses, in part because the two types have different endemics and different implications for management. Limestone cedar glades are naturally open due to shallow substrates, whereas prairies and barrens require anthropogenic fire to maintain them in open condition. However, the Florida areas have about equal proportions of the dominant annual and perennial grasses cited by the above authors and, in addition, a dominant perennial sedge whose relationship to soil depth has not been determined. In light of

their uniqueness, we will refer to them here as "Florida upland glades" as distinct from "limestone cedar glades" sensu Lawless et al. (2004). Florida upland glades are denoted as "panhandle Florida limestone prairie" by NatureServe (2012) at their association level of vegetation classification.

Florida upland glades were first recognized as a distinct community by Gholson (Ward & Gholson 1987) who began collecting specimens from River Junction and East Bank Campground glades in the 1970's (including the first examples from glades of species that are rare in Florida, e.g., *Delphinium carolinianum*, *Ratibida pinnata*, and *Symphyotrichum pratense*). The idea of Florida upland glades as a distinct community was bolstered in 1982, when, as part of a systematic survey of habitats and rare species along the east side of the Apalachicola River, Leonard and Baker (1982) discovered five more upland glades in Gadsden County with four species new to Florida (*Asclepias viridiflora*, *Echinacea purpurea*, *Stachys crenata*, and *Symphyotrichum shortii*) and one new to the Apalachicola region (*Callirhoe papaver*). Continued collecting by Gholson, J.B. Nelson, R.K. Godfrey, and others on these upland glades, as well as on some in Jackson County, resulted in the finding of more rare species, range extensions, and species new to Florida (including *Primula meadia*, *Salvia urticifolia*, and *Sporobolus vaginiflorus*; Anderson [1984, 1988, 1989, 2007]). Other publications reported the finding of individual species new to Florida, including *Bouteloua curtipendula* (Nelson 1985), *Lepuropetalon spathulatum* (Ward & Gholson 1987), and *Carex microdonta* (Bridges et al. 1989) and included short descriptions of the glades vegetation, with the result that the current list of known rare species from the Florida upland glades was fairly complete by the end of the 1980s. In 1987 Nelson, Anderson, and Gholson compiled a preliminary species list for the Gadsden County glades which was updated by Gholson in 1990. The present paper builds on the preliminary list for the Gadsden County glades, adds species from the Jackson County glades, and places the flora of the Florida upland glades in the context of other well-studied calcareous glades and prairies to the north and west. It is hoped this publication will spur recognition of the biogeographical significance of the Florida upland glades and lead to protection of at least some of the better preserved examples.

PHYSICAL SETTING

Geology

Florida upland glades occur in two clusters about 40 km apart. The cluster of eleven Gadsden County glades (plus a twelfth glade just over the border in Georgia, which will hereafter be included with the Gadsden County glades) are scattered within a 47 km^2 area north, south, and southeast of the town of Chattahoochee along the uplands bordering the eastern side of the Apalachicola River (Fig. 2). They occur at an elevation of 27.4–30.5 m above mean sea level (90–100 ft contour line) and are underlain by the Chattahoochee Formation of lower Miocene age, a silty, sandy dolomite with occasional occurrences of limestone, which dips steeply southward from a high point in the vicinity of Chattahoochee (Rupert 1990). The cluster of nine Jackson County glades are scattered within a 10 km^2 area west and northwest of the town of Marianna (Fig. 3). They occur between the 140- and 150-ft contour lines and are underlain by Marianna Limestone of lower Oligocene age, a white to light gray limestone 7.6–12.2 m thick which dips southward from a maximum elevation above mean sea level near Marianna of 45.7 m (150 ft; Moore 1955). The Marianna is a commercial grade limestone that is being actively mined in the vicinity of the glades.

Soils

Coultas (1983) sampled soils along transects across three glades in Gadsden County, with a total of 13 samples from open glades and 6 samples from forested edges of glades. Depth to hard limestone on the herb-dominated open glades ranged from 10 to 36 cm; on the forested edge of the glades it ranged from 53 to >152 cm. Soil texture on the open glades was generally silt loam in the upper layers, followed by several inches of soft limestone grading to hard limestone. On the forested edges, sandy loam in the upper layers gave way to clay and then to soft limestone followed by hard limestone. The open glades soils were more alkaline (pH 7.5) than the soils of the surrounding forests (pH ranging from 5.3 to 6.4). Coultas concludes from the lack of mottling in the subsoil of the open glades and the position of one of the sampled glades (#5 on Fig. 2) at the crest of a hill that they are not seepage areas and that woody invasion is probably controlled by the shallowness of the soils.

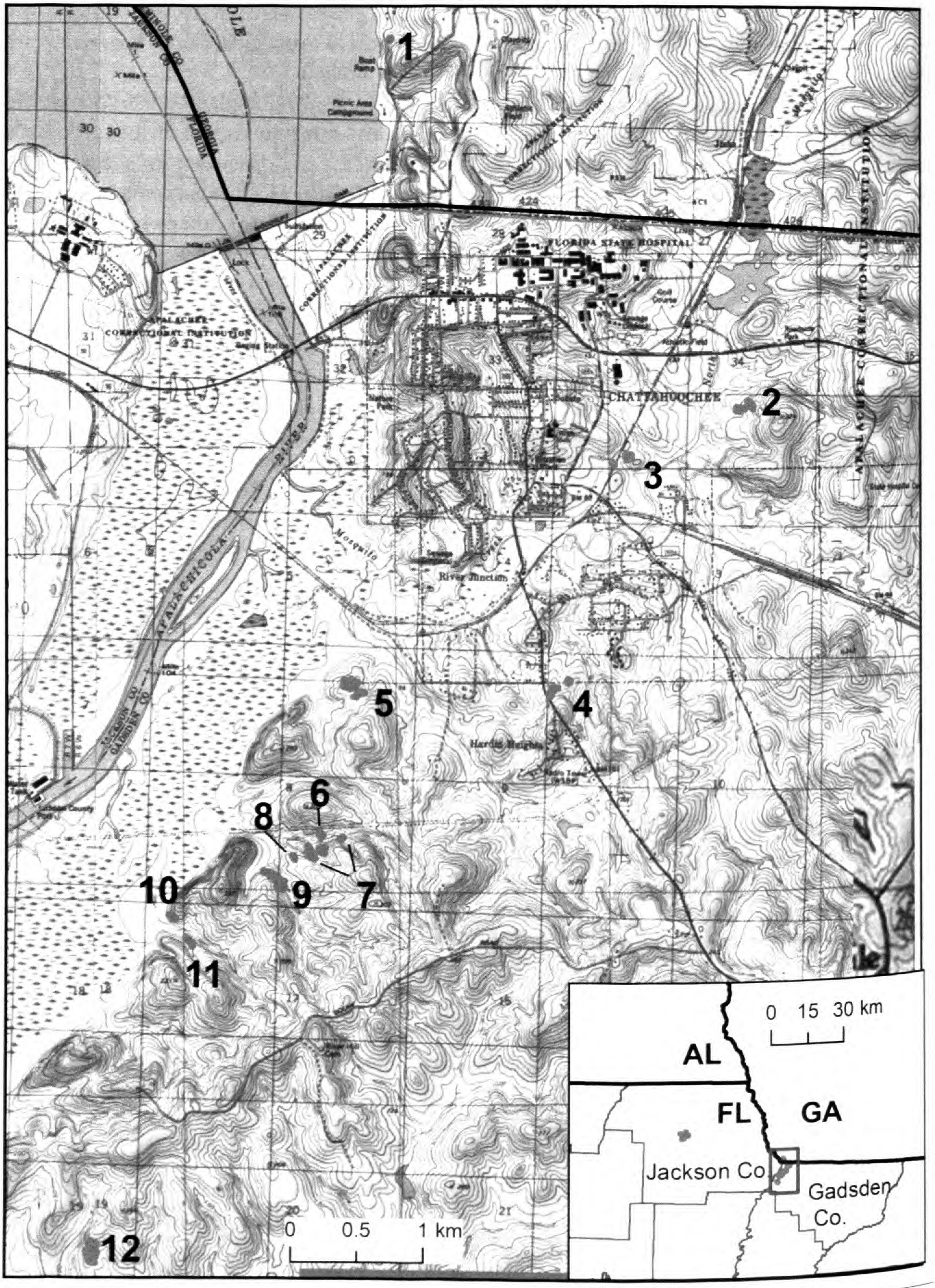


Fig. 2. Location of Gadsden County Glades. **1.** East Bank Campground; **2.** PRIDE; **3.** Railroad; **4.** River Junction; **5.** Brickyard; **6.** Powerline; **7.** EB; **8.** Selway Line; **9.** Chalky; **10.** Aster Shortii; **11.** Snake; **12.** Humphrey.

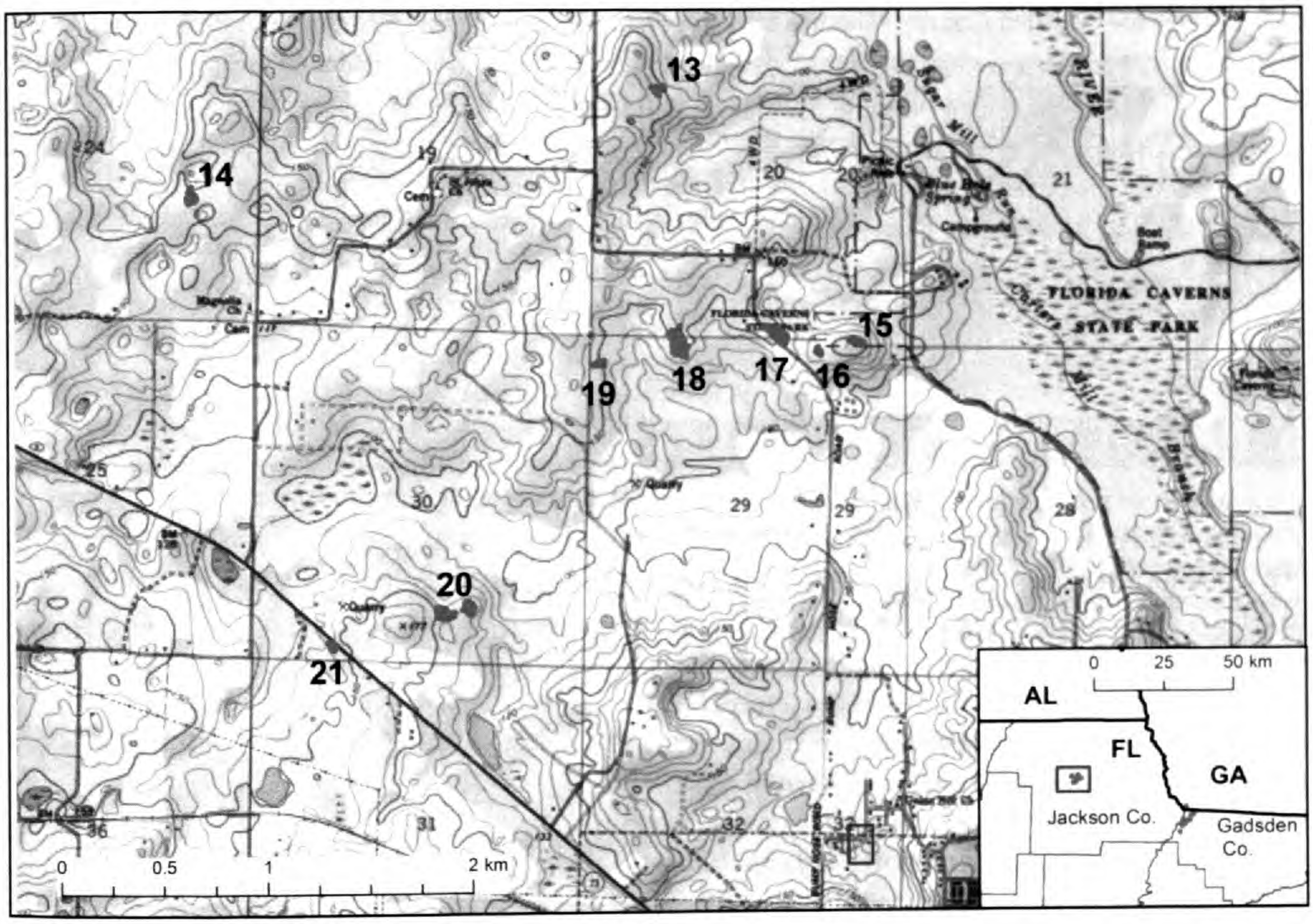


Fig. 3. Location of Jackson County Glades. **13.** Old Car; **14.** Williams-2; **15.** Moranz; **16.** Bennett, **17.** Bumpnose; **18.** Brooks-1; **19.** Brooks-4; **20.** Brooks-2; **21.** West of SR 73.

Climate

The area experiences mild winters and hot summers, with rainfall evenly distributed throughout the year. Mean daily maximum and minimum temperatures at Marianna are 18.2 and 5.24°C in January and 32.9 and 21.4°C in July; mean annual rainfall is 140.6 cm (Weather-Warehouse 2012). The average length of the growing season ranges from 260 to 280 days. Short drought periods occur most commonly in April and from September through November (Fernald & Purdum 1992).

METHODS

Twenty of the 21 glades were visited by the authors at least once in spring (March–June) and once in fall (September–November) between 2005 and 2012, and most were visited multiple times throughout the growing season. The exception was Snake glade, which was destroyed by road widening sometime between 1985 and 2005. Records for this glade are from four visits by Baker and Gholson in the 1980s. At each visit, species checklists were made and voucher specimens collected. Plants were listed from the open glade, from the edges, including the shrub zone between the open glade and the forested area around it, or the forest edge within 10 m of the open glade, if no shrub zone was present. Common non-vascular plant taxa and ground lichens were also noted, but no attempt was made to compile an exhaustive list of these taxa. Once a relatively complete list of vascular plant species was developed, the Angus Gholson herbarium (formerly AKG, now part of FLAS) and R.K. Godfrey herbarium (FSU) were searched for specimens from the glades to serve as further vouchers.

In 2005 one new glade was found and this spurred a systematic search of aerial photographs to identify potential new glades in the vicinity of known glades. Criteria used to distinguish glades openings from clearings were: (1) sites that remained open on all aerial dates consulted; i.e., 2004, 1999, 1994 for both counties,

plus 1954-55 for Gadsden County (Thomas et al. 1961) and 1969 for Jackson County (Duffee et al. 1979); (2) sites that were within or close to the elevation contour lines in which known glades occur in each county, i.e., 90-100 ft in Gadsden county and 140-150 ft in Jackson County; and (3) sites that had soils associated with known glades and/ or rock outcrop symbols on the soil survey maps for the respective counties. In Gadsden County these were Binnsville soils or Cuthbert, Boswell and Susquehanna soils on moderate to steep slopes (Thomas et al. 1961). In Jackson County, soils were the Oktibbeha variant rock outcrop complex (Duffee et al. 1979).

RESULTS AND DISCUSSION

New glades

In the search for new glades using aerial photography, fifty-one openings were identified in Jackson County and seventeen of these were field checked, yielding one relatively intact glade, Old Car, which was added to this study, and three possible former glades that are now highly disturbed. The latter three, in addition to one possible disturbed glade known prior to this study and one subsequently pointed out to us, brings to five the total of possible former glades confirmed on the ground in Jackson County. In Gadsden County, twenty-two potential glades were identified from aerial photography and nine of these were field checked. No new intact glades were found, but three possible former glades were identified, which, along with one possible former glade subsequently pointed out to us, brings to a total of four the number of possible former glades identified on the ground in Gadsden County. Possible former glades were identified by presence of characteristic glades dominants, such as *Muhlenbergia capillaris, Rhynchospora divergens*, *Sporobolus vaginiflorus,* or *Stenaria nigricans,* plus characteristic forbs such as *Polygala boykinii*. The non-native centipede grass (*Eremochloa ophiuroides*) is the principal invading species on former glades, where it often forms a dense turf, apparently precluding further colonization by native glades species.

In addition to the larger graminoid-dominated glades, small glade-like openings in forested areas with some of the characteristic glades forbs are known from four areas: Three Rivers State Park in Jackson County, the Angus Gholson Nature Park in Chattahoochee, an area along the Florida-Georgia line north of Chattahoochee, and an area known as "Brooks-3" west of Marianna in Jackson County.

Vegetation

Vegetation of the twenty-one glades consists of an open graminoid-dominated portion bordered by a characteristic set of calciphile shrubs and small trees that grade into the surrounding forest matrix on deeper soils (Fig. 4a–b). These shrubs and small trees may also form clumps or islands on the open glade. The surrounding forests (where still intact) consist of mesic upland hardwood forests on the steeper lower slopes, and pine-oak-hickory forests, or, in a few cases, remnants of longleaf pine/wiregrass pinelands, on the gentler upper slopes.

Juniperus virginiana is the predominant woody species found on the open glades and on the edges. Other shrubs and small trees consistently present on the edges of most glades are *Celtis laevigata, Cercis canadensis, Cornus asperifolia, Fraxinus americana, Ilex vomitoria, Myrica cerifera, Rhamnus caroliniana, Sideroxylon lanuginosum, S. reclinatum,* and *Viburnum rufidulum*. There is some differentiation between the two counties in common woody species found on the glades. *Acer saccharum* ssp. *floridanum* is more common in Gadsden County and *Quercus muhlenbergii* is more common in Jackson County. *Crataegus spathulata, C. pulcherrima*, and *Ulmus alata* are found on glades only in Gadsden County.

Dominant species of the herbaceous portion vary from glade to glade and from place to place within a glade. *Schoenus nigricans*, a large, clump-forming sedge, forms dense, nearly monospecific stands at sixteen of the twenty-one glades studied (Fig. 4a). Other large graminoids dominating portions of glades are *Muhlenbergia capillaris, Sporobolus junceus,* and *Schizachyrium scoparium*. A short turf composed of *Sporobolus vaginiflorus* and/or *Rhynchospora divergens* (Fig. 4b) is often found on other portions of the glades. Additional small grasses commonly found on the glades include *Aristida longispica, A. oligantha, Sporobolus clandestinus, Schizachyrium tenerum*, and *Panicum flexile*. Areas with much bare soil or broken rock at the surface support *Stenaria nigricans*, along with the moss *Weissia jamaicense* and a cyanobacterium, *Nostoc* sp. Characteristic







FIG. 4. **a.** Glade dominated by pure stand of *Schoenus nigricans*, flowering in foreground. b. glade dominated by short turf of *Sporobolus vaginiflorus* and *Rhynchospora divergens* in foreground with scattered clumps of *Schoenus nigricans* in background. **c.** glabrous-leaved coreopsis (*Coreopsis* sp. aff. *lanceolata*) on a Jackson County glade. Photos by first author.

herbs found at nearly all the glades include *Allium canadense* var. *mobilense*, *Asclepias viridiflora*, *Carex cherokeensis*, *Polygala boykinii*, *Nothoscordum bivalve*, *Ratibida pinnata*, *Rhynchospora colorata*, and *Sabatia angularis*.

A number of characteristic herbaceous species of the glades were found only in one county or the other, but not both. *Piriqueta cistoides* ssp. *caroliniana*, *Selaginella apoda* var. *ludoviciana*, *Callirhoe papaver*, and *Symphyotrichum pratense* were present on the majority of Gadsden County glades, but were absent from those in Jackson County. *Coreopsis* sp. (aff. *lanceolata*), *Rudbeckia triloba*, and *Packera anonyma* occurred on the majority of Jackson County glades and were absent from those in Gadsden County. Dispersal or substrate may contribute to these differences. The glade clusters in the two counties are at least 40 km apart, separated by the floodplain of the Apalachicola River. In Gadsden County the glades substrate is dolomite, whereas in Jackson County it is limestone.

Floristics

The total number of taxa noted either on, or around the edge of, the twenty-one glades is 311, of which 302 are vascular plant species (Appendix). Ninety-eight species were found only on the edge of the glades. Of the vascular plants, 280 are native, 21 non-native, and one adventive from the west (*Oenothera speciosa*). The largest family represented is Asteraceae with 50 species, followed by Poaceae (39), Cyperaceae (13), and Lamiaceae (12). Fabaceae (11) is typically one of the three largest families in the floras of other calcareous glades and prairies, but is here tied with Rosaceae for fifth place.

Nine of the non-native species on Florida upland glades are considered invasive by the Florida Exotic Pest Plant Council (FLEPPC 2011; Table 1). Of these, only the three species of *Ligustrum* were frequently noted on the Florida upland glades. Two non-native species not listed as invasive by the FLEPPC, *Eremochloa ophiuroides* and *Pyracantha koidzumii*, were also frequently noted on disturbed glades and, together with the *Ligustrum* species, tend to make up the majority of the cover of non-native species on these glades.

Fifteen glades species are tracked by the Florida Natural Areas Inventory (FNAI 2012) as rare in Florida (Table 2). Fourteen of these are also listed as endangered by the state of Florida (Florida Department of Agriculture and Consumer Services 2004). Most of these are northern calciphiles near their southern range limit in

TABLE 1. Invasive non-native species on Florida glades (n=11); * = species not listed by the Florida Exotic Pest Plant Council but which are a threat to Florida glades; FLEPPC Category I - species that are invading and disrupting native plant communities in Florida; FLEPPC Category II - species that have shown a potential to disrupt native plant communities.

Species	FLEPPC-Category I	FLEPPC-Category II
*Eremochloa ophiuroides**		
Imperata cylindrica	X	
Ligustrum japonicum	X	
Ligustrum lucidum	X	
Ligustrum sinense	X	
Lonicera japonica	X	
Lygodium japonicum	X	
Melia azedarach		X
Nandina domestica	X	
*Pyracantha koidzumii**		
Sapium sebiferum	X	

TABLE 2. Rare species on Florida upland glades (n=15). FNAI rankings are at the global (G) and state (S) levels: 1- critically imperiled because of extreme rarity; 2-imperiled because of rarity; 3-very rare or local; 4-secure; 5-demonstrably secure; ?-rank provisional; state of Florida ranking: LE-listed endangered (native species in imminent danger of extinction in state due to rarity).

Species	FNAI	State
Asclepias viridiflora	G5 S1	LE
Callirhoe papaver	G5 S2	LE
Carex microdonta	G4 S1	LE
Delphinium carolinianum	G5 S1	LE
Echinacea purpurea	G4 S1	LE
Euphorbia commutata	G5 S2	LE
Lepuropetalon spathulatum	G4G5 S1	LE
Matelea baldwyniana	G3 S1	LE
Matelea flavidula	G4? S1	LE
Matelea floridana	G2 S2	LE
Primula meadia	G5 S1	LE
Rudbeckia triloba	G5 S2	LE
Salvia urticifolia	G5 S1	LE
Stachys crenata	G5 S1	LE
Symphyotrichum pratense	G4? S1	

Florida. Only one, *Matelea floridana*, is globally rare, the rest being rare in Florida, but relatively secure over their total range (NatureServe 2012).

Six species appear to be largely confined to the Jackson and/or Gadsden County glades and are not found elsewhere in Florida (Wunderlin and Hansen 2011and personal observations of authors): *Asclepias viridiflora, Bouteloua curtipendula, Coreopsis* sp. (aff. *lanceolata*), *Ratibida pinnata*, *Sporobolus vaginiflorus*, and *Symphyotrichum pratense*. The moss, *Pleurochaete luteola*, was only known from the Jackson county glades, but has just recently been found on a limestone outcrop along the St Marks River in Wakulla County, Florida (first author, pers. obs.). Four others are known in Florida only from the edges and vicinity of glades: *Delphinium carolinianum, Echinacea purpurea, Primula meadia,* and *Symphyotrichum shortii*.

Coreopsis sp. (aff. *lanceolata*) is characterized by infolded, narrow, glabrous leaves which distinguish it from *C. lanceolata* (Fig. 4c). It is frequent on all nine Jackson County glades, as well as on the five possible former glades in that county. It is absent from Gadsden County glades where *Coreopsis lanceolata* is found on eight of the twelve glades. This narrow-leaved glabrous *Coreopsis* has not been observed by us in habitats other than

glades and maintains its distinctness from *C. lanceolata* when the two are grown together from seed in a common garden (first author, pers. observation).

Pleurochaete luteola has not previously been reported from Florida. In the New World it ranges on calcareous substrates from Virginia west to New Mexico and south to South America (Flora of North America Editorial Committee 2007 vol. 27). It can form the dominant ground cover in semi-shaded cedar glades in Tennessee (Quarterman 1950), is known from the Ketona Dolomite glades in Bibb County, Alabama (Allison & Stevens 2001), and was noted by the first author in 2009 at a blackland prairie at Oaky Woods Wildlife Management Area, Houston County, Georgia. In Florida we found it on two glades in Jackson County, in both cases as a single isolated patch in partial shade of *Juniperus virginiana*.

Symphyotrichum pratense is a western disjunct whose main range is centered on prairies in eastern Texas, Louisiana, and Arkansas (Jones et al. 2008). Eastward from its central range, it has widely scattered disjunct populations in open calcareous habitats in MS, AL, GA, TN, KY, and VA. The Florida population at the Gadsden glades is an isolated outpost at the southeastern extreme of its range (Jones et al. 2008, Fig. 2). Three other western species, *Callirhoe papaver*, *Hymenopappus scabiosaeus*, and *Linum medium* var. *texanum*, are frequent on Florida upland glades, but rare or absent on the Alabama blackbelt prairies, Ketona Dolomite glades, and Oaky Woods sites.

Like *Pleurochaete luteola*, *Bouteloua curtipendula* is very rare on Florida upland glades where it is at the southern limit of its range. It is common on glades and calcareous prairies to the north and west (Baskin & Baskin 2003; Campbell & Seymour 2012; Morris et al. 1993).

Of the 311 species listed, the number found at individual glades ranged from 43 to 162 (Table 3) and the average number per glade (excluding Snake which was not sampled as intensively as the others) was 105. Sorenson's Index of Similarity, i.e., the percentage of the average number of species in two glades that are held in common (Mueller-Dumbois & Ellenberg 1974), was calculated for six of the more intact glades, three in Gadsden (Brickyard, EB, and Humphrey) and three in Jackson County (Brooks-1, Bumpnose, and Old Car). Similarities ranged from 66-69% among the three Gadsden glades and 66 to 71% among the three Jackson glades. Pairwise comparisons between glades from the two different counties showed somewhat lower similarities, ranging from 53 to 63%. A value >50% is generally required for samples to be considered part of the same plant community (Barbour et al. 1980).

Comparison with floras of other calcareous openings

The percentage of Florida upland glades species found on other calcareous glades and prairies in the Southeast was determined from a literature review. Table 4 shows a comparison with sites where relatively comprehensive species lists over the entire growing season were compiled. Perhaps not surprisingly, the Florida upland glades have the highest number of species in common with those areas closest to them, namely, the blackbelt prairies in Georgia, Alabama, and Mississippi, and the Ketona Dolomite glades of Alabama, with decreasing numbers of species in common with sites farther to the north (TN, AL, GA glades) and west (isolated calcareous prairies in LA and TX). Comparison with species lists combined from a number of sites, compiled from the literature for the AL/ MS blackbelt prairies and for the Southeastern cedar glades, shows the same pattern.

Occurrence of some common Florida upland glades species at nearby calcareous sites (listed in Table 4) are shown in Table 5. Species common on Florida glades that also occur on most other calcareous openings in the Southeast include two of the most characteristic Florida upland glades species, found in few other habitats in the state, *Asclepias viridiflora* and *Sporobolus vaginiflorus*. Common Florida upland glades species found only on the closest sites (Ketona Dolomite glades, AL/MS blackbelt, and Oaky Woods) are generally southern coastal plain species. An example is *Evolvulus sericeus*, which reaches its northern range limit in Georgia (Bridges & Orzell 1989). This is also largely true of common Florida upland glades species that are absent from other calcareous openings to the north and west. Among these is a dominant species on Florida upland glades, *Schoenus nigricans*, which is spottily distributed from northern Europe to South Africa and North America. In the U.S it is found in Florida, Texas, California, and Nevada. Over its entire range it spans a wide diversity of habitats from acid bogs in northern Europe to hot springs in California (Munz & Keck 1959; Sparling 1968). In

TABLE 3. Characteristics of the 21 Florida glades studied. Dominant species: **Sn**=*Schoenus nigricans*, **Sv**=*Sporobolus vaginiflorus*, **Rd**=*Rhynchospora divergens*; **Mc**=*Muhlenbergia capillaris*. *Snake glade was visited 4 times prior to 2005.

No. on map	Glade	County	Size (ha)	No. of species	No. of visits (2005–2012)	Dominant species	Current condition	Ownership
1	East Bank Campground	Decatur, GA	0.02	58	4	Rd/Sv	good	private
2	PRIDE	Gadsden	0.05	82	4	Rd/Sv	partly disturbed	state
3	Railroad	Gadsden	0.20	98	4	Sn	good	state
4	River Junction	Gadsden	0.20	120	8	Sn/Rd	partly disturbed	private
5	Brickyard	Gadsden	0.59	135	14	Sn/Rd/Sv	good	private
6	Powerline	Gadsden	0.05	113	15	Rd	partly disturbed	private
7	EB	Gadsden	0.39	142	12	Sn/Rd/Sv	good	private
8	Selway line	Gadsden	0.03	78	6	Sn	good	private
9	Chalky	Gadsden	0.43	135	6	Sn	good	private
10	Aster shortii	Gadsden	0.09	88	4	Rd	partly disturbed	private
11	Snake*	Gadsden	0.09	43	0	Rd	destroyed	private
12	Humphrey	Gadsden	0.60	124	5	Sn/Rd/Sv	good	private
13	Old car	Jackson	0.13	112	9	Rd/Sv/Mc	good	private
14	Williams-2	Jackson	0.21	121	10	Sn	partly disturbed	private
15	Moranz	Jackson	0.10	105	10	Sn	good	state
16	Bennett	Jackson	0.06	71	7	Sn/Rd/Sv	partly disturbed	private
17	Bumpnose	Jackson	0.39	123	13	Sn/Rd/Sv	partly disturbed	private
18	Brooks-1	Jackson	0.76	162	15	Sn/Rd/Sv/Mc	good	private
19	Brooks-4	Jackson	0.11	67	3	Sn	destroyed	private
20	Brooks-2	Jackson	0.59	95	2	Sn	destroyed	private
21	West of SR 73	Jackson	0.11	71	7	Mc	partly disturbed	private

Florida it occurs on moist to wet calcareous substrates in the panhandle, throughout south Florida, and in two counties on the central west coast of the peninsula (Wunderlin & Hansen 2008). Of the twenty-seven species frequently found on nearby calcareous openings but not found on Florida glades, six occur in Florida in other habitats and the rest do not range south to Florida. Five of these have their centers of distribution in the West or Midwest and are disjunct to the east on calcareous glades and prairies (Bridges & Orzell 1986; Brown 2003).

CONCLUDING REMARKS

In terms of dominant species, Florida upland glades differ from other calcareous glades and prairies to the north and west in the dominance of species in the Cyperaceae (*Schoenus nigricans, Rhynchospora divergens*) and the relative paucity of species in the Fabaceae.

Questions outside the scope of this paper that remain for future studies to answer include the relative roles soil texture, soil depth, and fire frequency have in controlling woody colonization of the Florida upland glades, plus the relative roles of disturbance and soil depth in determining the distribution of herbaceous dominants within any single glade.

In the context of the rest of the Southeast, the Florida upland glades can be considered a somewhat anomalous southeastern outpost of a series of calcareous glades and prairies extending eastward from Texas through Louisiana, Mississippi, Alabama, and Georgia. From an examination of aerial photographs of potential glade openings in the two Florida counties, it appears likely that glade openings were more numerous in pre-settlement times, but probably did not extend much further geographically than at present. The Florida upland glades community (denoted as "upland glade") is ranked G1S1 (critically imperiled) by the Florida Natural Areas Inventory (FNAI 2010) and is the only highly ranked community in Florida without a prominent site under protection. Currently one small Florida glade is protected on a state park (Moranz) and two (Railroad and Pride) are on public land that is not actively managed for their protection. Of those on private land, two have been destroyed by mining (Brooks-4 and Brooks-2) and five (Bumpnose, Brooks-1, Brickyard, *Aster*

TABLE 4. Comparison of the species list for Florida upland glades with species lists for other calcareous openings in the Southeast.

Site	Number of native species in common with Florida (percent of Florida's total)	Total no. of native species	Distance from Florida glades (km)
Lists from single studies:			
FL: Jackson and Gadsden County glades (this study)	281 (100%)	281	N/A
GA: Oaky Woods Wildlife Management Area, GA (Echols & Zomlefer 2010)	137 (48.7%)	319	225
AL: Ketona Dolomite outcrops, AL (Allison & Stevens 2001)	132 (46.9%)	320	340
AL: blackbelt prairies (Schotz 2011)	122 (43.4%)	245	~260
MS: blackbelt prairie (Pulliam Prairie)(Campbell & Seymour 2012)	120 (42.7%)	415	513
LA: Kisatchie National Forest, Keiffer and Packton prairies (MacRoberts & MacRoberts 1995, 1996)	94 (33.4%)	193	745
TX: Windham Prairie, TX (Brown et al. 2002)	90 (32%)	217	964
Composite lists from several studies:			
MS/AL blackbelt prairies -from literature (Campbell & Seymour 2012)	141 (50.2%)	508	500-230
Southeastern cedar glades (TN KY,AL,GA,VA)-from literature (Baskin & Baskin 2003)	119 (42.3%)	450	~450

TABLE 5. Occurrence of Florida glades species on other calcareous openings in the Southeast (cited in Table 4).

SPECIES COMMON THROUGHOUT (Species present on most Florida glades as well as on most other calcareous openings in Southeast.)	ON FLORIDA GLADES AND NEARBY AREAS ONLY (Species present on most Florida glades that are shared only with the closest calcareous openings: O=Oaky woods; K=Ketona Dolomite glades; A= AL, MS blackbelt prairies; L= LA Kisatchie prairies.	ON FLORIDA GLADES ONLY (Species present on most Florida glades and not listed from other calcareous openings in Southeast.)	COMMON THROUGHOUT BUT NOT ON FLORIDA GLADES (Species frequently listed on the closest calcareous openings but absent from Florida glades; nomenclature for species not in Florida (*) follows Weakley 2012; [1]=western disjunct.
Aristida longispica	*Allium canadense var. mobilense*-K,A	*Carex gholsonii*	*Anenome berlandieri*
Asclepias verticillata	*Asemeia (Polygala) grandiflora*-K,A	*Coreopsis* sp. (aff. *lanceolata*)	*Blephillia ciliata**
Asclepias viridiflora	*Evolvulus sericeus*-A	*Cornus foemina*	*Carex granularis**
Berchemia scandens	*Fleischmannia incarnata*-O,K	*Eremochloa ophiuroides*	*Chamaesyce nutans*
Brickellia eupatorioides	*Liatris elegantula*-O,A	*Piriqueta cistoides* ssp. *caroliniana*	*Cornus drummondii**
Carex cherokeensis	*Myrica cerifera*-O,K,L	*Schoenus nigricans*	*Dalea candida**[1]
Cercis canadensis	*Rhynchospora colorata*-K,A	*Selaginella apoda* var. *ludoviciana*	*Dalea purpurea**[1]
Diospyros virginiana	*Rhynchospora divergens*-K,A	*Sideroxylon reclinata*	*Desmanthus illinoensis*
Erigeron strigosus	*Rhynchospora globularis*-K		*Echinacea pallida**[1]
Fraxinus americana	*Ruellia carolinensis*-O,A		*Eurybia hemispherica*
Juniperus virginiana	*Sabal minor*-K		*Heliotropium tenellum**[1]
Manfreda virginica	*Sporobolus junceus*-K,A,L		*Houstonia purpurea* var. *calycosa**
Nothoscordum bivalve	*Thaspium barbinode*-K		*Hypericum sphaerocarpum**[1]
Panicum flexile			*Lithospermum canescens**
Plantago virginica			*Lobelia spicata**
Sabatia angularis			*Nemastylis geminiflora**
Salvia lyrata			*Neptunia lutea**[1]
Schizachyrium scoparium			*Polytaenia nuttallii**
Setaria parviflora			*Rhus aromatica*
Sporobolus clandestinus			*Ruellia humilis**
Sporobolus vaginiflorus			*Silphium laciniatum**
Stenaria nigricans			*Sisyrinchium albidum*
Tridens flavus			*Solidago (Oligoneuron) rigida**
Ulmus alata			*Sorghastrum nutans*
Viburnum rufidulum			*Spiranthes magnicamporum**
			*Symphyotrichum novae-angliae**
			*Trichostema bractiata**

shortii, and Williams-2) have been heavily to partially disturbed by roads, food plots, or parking of heavy machinery, since the onset of this study in 2005. Clearly the seven largest, mostly intact glades (EB, Humphrey, Chalky, and Brickyard in Gadsden County; Bumpnose, Brooks-1, and Old Car in Jackson County) will remain in jeopardy until protected, either by acquisition as public lands or by conservation easement.

APPENDIX

Annotated list of vascular plant taxa on 21 upland glades in Jackson and Gadsden counties, Florida (n=302), plus a cyanobacterium and some common moss and ground lichen taxa (n=9). Nomenclature for vascular plants follows Wunderlin and Hansen (2011), for mosses Crum and Anderson (1981), and for lichens Brodo et al. (2001), except where otherwise noted. Underlined taxa are common on, and/or characteristic of, these glades; FNA=Flora of North America Editorial Committee; [1]=listed as endangered or threatened by the state of Florida, [2]=tracked as rare by the Florida Natural Areas Inventory,*= non-native; J-1,G-2= number of glades where found in Jackson County (n=9) and Gadsden County (n=12); O=open glade, E=edge of glade, i.e. near or under the zone of shrubs commonly bordering the glades, V=vicinity of glade; abundance (within individual glades, not across all glades): rare, infrequent, occasional, local, frequent, common; specimen collector and collection number (AFJ, LCA, WWB, and AKG are the authors, JBN is John B. Nelson, and MAG is Mark A. Garland). Except where otherwise noted, AKG specimens are deposited in University of Florida herbarium (FLAS) and all others are deposited in R.K. Godfrey herbarium at Florida State University (FSU); + indicates additional specimens from Florida glades are present in the respective herbarium collections.

CYANOBACTERIA

Nostocaceae

Nostoc sp., witches' jelly; J-7, G-8; O (common)

LICHENS

Cladoniaceae

Cladina evansii (Abbayes) Hale & W.L. Culb., powder-puff lichen; J-2, G-1; O,E (rare)

Cladina subtenuis (Abbayes) Hale & W.L. Culb., Dixie reindeer lichen; J-5, G-10; O,E (infrequent)

MOSSES

Brachytheciaceae

Bryoandersonia illecebra (Hedw.) H. Robin., wormy moss; J-1, G-2; E (local patches); AFJ 10344 (FLAS)+

Fissidentaceae

Fissidens cristatus Wilson ex Mitt., pocket moss; G-1; E (rare)

Funariaceae

Funeria hygrometrica Hedw., bonfire moss; J-5, G-1; O (local patches in disturbed areas); AFJ s.n. (5 February 2009, Brickyard; FLAS)

Pottiaceae

Pleurochaete luteola (Bescherelle) Theriot (FNA 2007 vol. 27), glades moss; J-2, O,E (rare); AFJ 10245 (FLAS)+

Weissia jamaicense (Mitt.) Grout, twisted moss; J-7, G-8; O (common); AFJ 10364 (FLAS)+

Thuidiaceae

Thuidium delicatulum (Hedw.) BSG, delicate fern moss; J-2; E (infrequent); AFJ s.n. (17 October 2007, Old Car; FLAS)

FERNS and FERN ALLIES

Dennstaedtiaceae

Pteridium aquilinum (L.) Kuhn, bracken fern; J-1, G-2; E (infrequent)

Ophioglossaceae

Ophioglossum petiolatum Hook., stalked adders-tongue; J-1; O (rare)

Polypodiaceae

Pleopeltis polypodioides (L.) E.G. Andrews & Windham var. *michauxiana* (Weath.) E.G. Andrews & Windham, resurrection fern (on *Juniperus virginiana*); J-6, G-4; O (occasional), E (common)

Selaginellaceae

Selaginella apoda (L.) Fernald var. *ludoviciana* (A. Braun) B.F. Hansen & Wunderlin, Gulf spike-moss; G-11; O,E (local patches); LCA 9199

Schizaeaceae

*Lygodium japonicum** (Thun.) Sw., Japanese climbing fern; J-7, G-9; O,E (infrequent)

Thelypteridaceae

Thelypteris kunthii (Desv.) C.V. Morton, widespread maidenfern; G-4; E (infrequent to locally common); AFJ 10523+

GYMNOSPERMS

Cupressaceae

Juniperus virginiana L., eastern red cedar, J-9, G-12; O,E (occasional to common)

Pinaceae

Pinus echinata Mill., shortleaf pine; G-3; E (infrequent)

Pinus glabra Walter, spruce pine; G-2; E (infrequent)

Pinus palustris Mill., longleaf pine; G-2; E,V (rare)

Pinus taeda L., loblolly pine; J-9, G-9; O (occasional –mostly as seedlings), E (frequent)

ANGIOSPERMS

Acanthaceae

Dyschoriste oblongifolia (Michx.) Kuntze, oblongleaf twinflower; G-2; O (rare)

Elytraria carolinensis (J.F. Gmel.) Pers., Carolina scalystem, G-8; O,E (occasional); JBN 2739.

Ruellia caroliniensis (J.F. Gmel.) Steud., Carolina wild petunia, J-9, G-11; O (occasional); LCA 21493

Adoxaceae

Viburnum dentatum L., arrow-wood; J-1, G-3; E (infrequent)

Viburnum obovatum Walter, Walter's viburnum; J-2, G-8; E (occasional); LCA 21858

Viburnum rufidulum Raf., rusty black-haw; J-5, G-5; E (frequent)

Agavaceae

Manfreda virginica (L.) Salisb. ex Rose, false aloe; J-7, G-8; O (infrequent); LCA 21232+

Yucca aloifolia L., Spanish bayonet; J-1; E (local); LCA 21910

Yucca filamentosa L., Adam's needle; J-3, G-9; O (occasional)

Alliaceae

Allium canadense L. var. *mobilense* (Regel) Owenbey, meadow garlic; J-7, G-11; O (frequent); LCA 10485 +

Nothoscordum bivalve (L.) Britton, false garlic; J-7, G-12; O (frequent)

Altingiaceae

Liquidambar styraciflua L., sweetgum; J-2, G-3; E (occasional)

Anacardiaceae

Rhus copallinum L., winged sumac; J-7, G-5; O,E (infrequent)

Toxicodendron radicans (L.) Kuntze, poison ivy; J-5, G-5; O,E (infrequent)

Apiaceae

Chaerophyllum tainturieri Hook., hairyfruit chervil; G-3; O (occasional-disturbed areas)

Eryngium yuccifolium Michx., button eryngo; J-2, G-1; O,E (infrequent)

Thaspium barbinode (Michx.) Nutt., hairyjoint meadowparsnip; J-6; E,V (frequent); LCA 21905+

Thaspium trifoliatum (L.) A. Gray, purple meadowparsnip; G-7; E (locally common); LCA 21845, AKG 10396

Zizia aurea (L.) Koch, golden alexanders; G-7; O,E (occasional),V (locally common); LCA 21841+, AKG 10919+

Apocynaceae

Apocynum cannabinum L., dogbane; J-1, G-1; E (rare)

Asclepias tuberosa L., butterflyweed; J-3; E (rare)

Asclepias verticillata L., whorled milkweed; G-8; O (infrequent); JBN 2743

Asclepias viridiflora[1,2] Raf., green milkweed; J-9, G-9; O (occasional); LCA 20772+, AKG 11436+

Asclepias viridis Walter, green antelopehorn; G-2; E,V (rare); RKG 81249, AKG 9777

Gonocarpos suberosa (L.) R.Br., angle pod; J-3, G-6; O,E (rare), V (occasional); LCA 21839

Matelea baldwyniana[1,2] (Sweet) Woodson, Baldwin's spinypod; G-2; E,V (infrequent)

Matelea flavidula[1,2] (Chapm.) Woodson, Carolina milkvine; G-1; E,V (rare)

Matelea floridana[1,2] (Vail) Woodson, Florida milkvine; J-1; E (rare); LCA 21921+

Aquifoliaceae

Ilex vomitoria Aiton, yaupon; J-8, G-9; O (rare), E (common)

Arecaceae

Sabal minor (Jacq.) Pers., blue palmetto; J-1, G-10; O,E (infrequent)

Serenoa repens (W. Bartram) Small, saw palmetto; G-3; E (rare)

Aristolochiaceae

Aristolochia serpentaria L., Dutchman's pipe; J-2, G-1; E,V (rare)

Asteraceae

Ambrosia artemisiifolia L., common ragweed; J-5, G-2; O (rare)

Ambrosia psilostachya DC., western ragweed; J-1; E (rare); LCA 21377

Baccharis halimifolia L., saltbush; J-2, G-4; O (rare-disturbed areas)

Bidens alba (L.) DC., beggerticks; J-1, G-2; O (rare-disturbed areas)

Brickellia eupatorioides (L.) Shinners, false boneset; J-4, G-4; O,E (infrequent); LCA 21504+, AKG 11521

Chaptalia tomentosa Vent., sunbonnets; G-3; O (rare)

Chrysopsis mariana (L.) Elliott, Maryland goldenaster; J-3; E (rare)

Cirsium altissimum (L.) Spreng., tall thistle; J-1; E (rare)

Cirsium horridulum Michx., horrible thistle; J-7, G-6; O (occasional)

Conoclinium coelestinum (L.) DC., blue mistflower; J-8, G-9; O (rare), E (frequent)

Conyza canadensis (L.) Cronquist, Canadian horseweed; J-1, G-1; O,E (rare-disturbed areas)

Coreopsis lanceolata L., lanceleaf tickseed; G-8; O (frequent); AFJ 10377a+

Coreopsis sp. (aff. *lanceolata*), Jackson glades tickseed; J-9; O (frequent); AFJ 10353a+

Echinacea purpurea[1,2] (L.) Moench, eastern purple coneflower; G-6; O (rare), E (common); LCA 21837, AKG 9811+

Erigeron strigosus Muhl. ex Willd., prairie fleabane; J-9, G-11; O (frequent); AFJ 10508, AKG 11272

Eupatorium capillifolium (Lam.) Small ex Porter & Britton, dogfennel; J-1, G-2; O,E (rare-disturbed areas)

Fleischmannia incarnata (Walter) R.M. King & H. Rob., pink thoroughwort; J-5, G-10; E (frequent); RKG 80088

Gaillardia aestivalis (Walter) H. Rock, lanceleaf blanketflower; J-5; O (occasional); LCA 21207+

Helenium amarum (Raf.) H. Rock, bitterweed; J-2; O (rare)

Helenium autumnale L., common sneezeweed; J-2, G-6; E (frequent)

Helianthus radula (Pursh.) Torr. & A. Gray, black sunflower; G-1; O (frequent); JBN 2754

Helianthus resinosus Small, resindot sunflower; J-1; E (infrequent); JBN 2802

Heliopsis gracilis Nutt. (FNA 2006 vol. 21), smooth oxeye; J-2, G-8; O,E (occasional); LCA 10483+, AKG 11016

Hymenopappus scabiosaeus L'Her., Carolina woollywhite; J-6; O (frequent); LCA 21962+

Liatris elegantula (Greene) K. Schum., grassleaf gayfeather; J-7, G-9; O (frequent); AFJ 10264+, AKG 11490 [=*L. graminifolia* Willd.]

Liatris squarrosa (L.) Michx., scaly gayfeather; G-2; O (occasional); AKG 12007

Liatris squarrulosa Michx., Appalachian gayfeather; J-1; E,V (rare); AFJ 10489

Melanthera nivea (L.) Small, snow squarestem; J-3, G-7; E (infrequent)

Packera anonyma (A.W. Wood) W.A. Weber & A. Love, golden ragwort; J-8; O,E (occasional); LCA 21205+

Pyrrhopappus carolinanis (Walter) DC., desert chicory; J-1; O (rare)

Ratibida pinnata (Vent.) Barnhart, prairie coneflower; J-6, G-6; O,E (common); LCA 21855+

Rudbeckia fulgida Aiton, orange coneflower; G-6; O,E (common); AFJ 10303+, AKG 10084

Rudbeckia triloba[1,2] L., browneyed susan; J-9; O,E (common); LCA 21175+

Silphium asteriscus L., starry rosinweed; J-8, G-8; E (occasional); AKG 10085

Solidago altissima L. (FNA 2006 vol. 20), tall goldenrod, J-3, G-2; O,E (rare); LCA 21442

Solidago auriculata Shuttlew. ex S.F. Blake, eared goldenrod; J-6; O,E (occasional); LCA 21464+

Solidago caesia L., bluestem goldenrod; J-1, G-2; E (frequent); LCA 21496+

Solidago nemoralis Aiton, Dyersweed goldenrod; G-3; O (common); AFJ 10459

Symphyotrichum concolor (L.) G.L. Nesom, Eastern silver aster; J-1, G-4; O,E (infrequent); WWB s.n. (1 November 2007, Brooks-1)

Symphyotrichum dumosum (L.) G.L. Nesom, rice-button aster; J-9, G-11; O (frequent); AFJ s.n. (1 November 2010, Brooks-1)+, AKG 10676

Symphyotrichum laeve (L.) A. Love & D. Love var. *concinnum* (Willd.) G.L. Nesom, smooth blue aster; J-4, G-1; E (occasional); LCA 21385+

Symphyotrichum lanceolatum (Willd.) G.L. Nesom var. *latifolium* (Semple and Chmiel.) G.L. Nesom, white panicle aster; J-1; E (rare); LCA 21455

Symphyotrichum lateriflorum (L.) A. Love & D. Love, calico aster; J-3, G-4; O,E (infrequent); LCA 21498+

Symphyotrichum oolentangiense (Riddell) G.L. Nesom, swordleaf wood aster; J-1, G-3; O,E (occasional); LCA 21492+

Symphyotrichum patens (Aiton) G.L.Nesom, late purple aster; J-1; O (rare); AFJ 10441

Symphyotrichum pilosum (Willd.) G.L. Nesom, white oldfield aster; J-2; E (rare); LCA 21456

Symphyotrichum pratense[2] (Raf.) G.L. Nesom (FNA 2006 vol. 20), western silver aster; G-7; O (occasional); AFJ s.n. (17 October 2007, EB West)+, AKG 11507

Symphyotrichum shortii (Lindl.) G.L. Nesom, Short's aster; J-2, G-5; E (rare); LCA 21440 FSU+

Symphyotrichum undulatum (L.) G.L. Nesom, wavyleaf aster; J-3, G-4; O,E (occasional); LCA 21511+

Verbesina virginica L., white crownbeard; J-4, G-8; O (rare), E (occasional)

Berberidaceae

*Nandina domestica** Thunb., heavenly bamboo; J-3, G-2; O,E (rare)

Betulaceae

Ostrya virginiana (Mill.) K. Koch, eastern hophornbeam; J-4, G-1; E (infrequent)

Bignoniaceae

Bignonia capreolata L., crossvine; G-2; O,E (rare)

Campsis radicans (L.) Seemann, trumpet creeper; J-5, G-1; O (rare), E (infrequent)

Boraginaceae

Lithospermum incisum Lehm., narrowleaf gromwell; J-2, G-1; O,E,V (rare); AFJ s.n.(12 May 2010, Brooks-1)+

Lithospermum tuberosum Rugel ex DC, tuberous gromwell; J-2, G-8; E (infrequent); LCA 9200

Onosmodium virginianum (L.) DC., false gromwell; G-3; O (infrequent); JBN 2728

Campanulaceae

Campanula americana L., American bellflower; J-4; O,E (rare); LCA 21368

Lobelia amoena Michx. var. *glandulifera* A. Gray, southern lobelia; G-2; E (rare); LCA 21483+

Lobelia puberula Michx., downy lobelia; J-1, G-3; O,E,V (occasional); LCA 21443+

Triodanis biflora (Ruiz & Pav.) Greene, small Venus' looking-glass; G-1; O,E (rare)

Triodanis perfoliata (L.) Nieuwl., Venus' looking-glass; J-2, G-2; O (infrequent)

Caprifoliaceae

*Lonicera japonica** Thunb., Japanese honeysuckle; J-5; O,E (infrequent)

Lonicera sempervirens L., coral honeysuckle; J-3, G-7; E (occasional)

Valerianella radiata (L.) Dufr., beaked cornsalad; J-1, G-1; O (rare-disturbed areas)

Celtidaceae

Celtis laevigata Willd., sugarberry; J-6,G-6; O (rare), E (occasional); RKG 80516

Celtis tenuifolia Nutt. (FNA 1997 vol. 3), dwarf hackberry; J-3; G-5; O,E (infrequent); AFJ 10241

Clusiaceae

Hypericum hypericoides (L.) Crantz, St. Andrew's-cross; J-4, G-7; O,E (infrequent); AFJ 10335

Commelinaceae

Commelina erecta L., whitemouth dayflower; G-2; E (rare); AFJ 10263

Convolvulaceae

Cuscuta pentagona Engelm., fiveangled dodder, J-1; O (rare); LCA 21380 (on *Liatris*)

Dichondra carolinensis Michx., ponysfoot; J-4, G-4; O,E (rare)

Evolvulus sericeus Sw., silver dwarf morning-glory; J-8, G-6; O (frequent); LCA 21911+, AKG 9706

Ipomoea cordatotriloba Dennst., tievine; J-1, G-1; O,E (rare)

Ipomoea pandurata (L.) G. Mey, man-of-the-earth; J-4, G-2; O,E (infrequent)

Cornaceae

Cornus asperifolia Michx., roughleaf dogwood; J-6, G-8; E (infrequent); LCA 21836+

Cornus florida L., flowering dogwood; J-6, G-4; E (occasional)

Cornus foemina Mill., swamp dogwood; J-5, G-7; E (occasional); LCA 20754+

Cyperaceae

Carex cherokeensis Schwein., Cherokee sedge; J-7, G-9; O,E (occasional); LCA 21601+, AKG 11273+

Carex gholsonii Naczi & Cochrane, Gholson's sedge; J-3, G-6; O (infrequent); LCA 20684+, AKG 11789

Carex microdonta[1,2] Torr. & Hook., littletooth sedge, G-3; O (common); LCA 11194+, AKG 11969

Carex striatula Michx., line sedge; J-2; E (occasional); LCA 21593

Carex styloflexa Buckley, bent sedge; G-2; E (rare); LCA 11222+

Fimbristylis puberula (Michx.) Vahl, hairy fimbry; J-6, G-7; O (frequent); AFJ s.n. (17 October 2007, Brickyard)+, AKG 9749

Rhynchospora colorata (L.) H. Pfeiff., whitetop sedge; J-2, G-10; O (frequent); JBN 2742

Rhynchospora divergens Chapman ex M.A. Curtis, spreading beaksedge; J-5, G-10; O (common); LCA 11206+, AKG 5136

Rhynchospora globularis (Chapm.) Small, globe beaksedge; J-4; G-8; O (frequent); AFJ s.n. (12 May 2010, Bumpnose)+

Schoenus nigricans L., black bogrush, J-7, G-9; O (common); LCA 21597+

Scleria oligantha Michx., littlehead nutrush, G-6; O (occasional); LCA 29914+

Scleria triglomerata Michx., tall nutgrass; J-2; O (rare)

Scleria verticillata Muhl. ex Willd., low nutrush; J-2, G-2; O (occasional); LCA 20750+

Dioscoreaceae

Dioscorea villosa L., wild yam; G-3; E (infrequent)

Ebenaceae

Diospyros virginiana L., persimmon; J-9, G-6; O,E (frequent)

Euphorbiaceae

Chamaesyce hyssopifolia (L.) Small, hyssopleaf sandmat; J-5, G-9; O (frequent); LCA 21856+, AKG 11078

Euphorbia commutata[1,2] Engelm. ex A. Gray, wood spurge; G-4; O,E (rare)

Euphorbia discoidalis Chapm., summer spurge; J-4, G-2; O (frequent); LCA 21441+

*Sapium sebiferum** (L.) Roxb., Chinese tallowtree; J-1, G-1; O,E (rare-disturbed areas)
Tragia cordata Michx., heartleaf noseburn; G-4; O,E (infrequent); LCA 21505
Tragia urticifolia Michx., nettleleaf noseburn; J-2, G-7; O,E (occasional); JBN 2738, AKG 9808

Fabaceae
Centrosema virginianum (L.) Benth., butterfly pea; J-6, G-4; O (rare), E (occasional)
Cercis canadensis L., redbud; J-8, G-12; O,E (common)
Crotalaria rotundifolia J.F. Gmel., rabbitbells; J-5; O,E (rare); AFJ 10300
Desmodium rotundifolium DC., prostrate ticktrefoil; J-2; O (rare); LCA 21388
Erythrina herbacea L., coral bean, J-2, G-1, E (rare)
*Lespedeza cuneata** (Dum Cours.) G. Don, Chinese lespedeza; J-1; O (rare)
Rhynchosia difformis (Elliott) DC., snoutbean; J-3; O,E (rare); LCA 21117
Rhynchosia reniformis DC., dollarleaf; J-2; O (infrequent)
Senna marilandica (L.) Link., Maryland wild sensitive plant; J-1; E (rare)
Strophostyles umbellata (Muhl. ex Willd.) Britton, pink fuzzybean; J-1; E (rare)
*Trifolium campestre** Shreb., field clover; J-2, G-1; O (rare)

Fagaceae
Quercus muhlenbergii Engelm., chinquapin oak; J-9, G-3; E (common); LCA 21452+
Quercus nigra L., water oak; J-1; E (infrequent)
Quercus shumardii Buckley, Shumard's oak; J-1; E (infrequent)
Quercus stellata Wangenh., post oak; J-1; E (infrequent)
Quercus virginiana Mill., live oak; J-8; G-3; E (frequent)

Gelsemiaceae
Gelsemium sempervirens (L.) W.T. Aiton, yellow jessamine; J-3, G-3; E (occasional)

Gentianaceae
Sabatia angularis (L.) Pursh., rosepink; J-9, G-7; O (frequent); LCA 21204+, AKG 10594

Hydrangeaceae
Hydrangea quercifolia W. Bartram, oakleaf hydrangea; G-1; E,V (rare)

Hypoxidaceae
Hypoxis wrightii (Baker) Brackett, bristleseed yellow stargrass; J-2, G-1; O (infrequent); AFJ 10394

Iridaceae
Sisyrinchium nashii E.P. Bicknell, Nash's blue-eyed grass; J-3, G-2; O,E (infrequent); LCA 21589+
*Sisyrinchium rosulatum** E.P. Bicknell, annual blue-eyed grass; J-4; O (infrequent-disturbed areas)

Juglandaceae
Juglans nigra L., black walnut; J-2; E (rare)

Lamiaceae
Callicarpa americana L., beautyberry; J-9, G-10; O (rare), E (common)
Hyptis alata (Raf.) Shinners, clustered bushmint; J-1, G-9; O,E (infrequent)
Pycnanthemum albescens Torr. & A. Gray ex A. Gray, whiteleaf mountainmint; J-1,G-1; O (rare); LCA 21200
Pycnanthemum setosum Nutt., awned mountainmint; J-1; O (rare); LCA 21912
Pycnanthemum tenuifolium Schrad., narrowleaf mountainmint, J-3; O,E (rare); LCA 21900+
Salvia azurea Michx. ex Lam., blue sage; J-4, G-9; O,E (frequent); MAG 1073+
Salvia lyrata L., lyreleaf sage; J-9, G-10; O (occasional)
Salvia urticifolia[1,2] L., nettleleaf sage; J-5, G-2; E,V (occasional); LCA 21366, AKG 11489+
Scutellaria integrifolia L., helmet skullcap; G-3; O (rare)
Scutellaria parvula Michx., small skullcap; G-3; O (rare); RKG 81983

Stachys crenata[1,2] Raf., shade betony; G-1; O (rare); LCA 11208+, AKG 9747
Trichostema dichotomum L., forked bluecurls; J-5, G-1; O (infrequent); AFJ 10443a

Lentibulariaceae
Pinguicula pumila Michx., small butterwort; G-1; O (local)

Linaceae
Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald, stiff yellow flax; J-6, G-6; O (occasional); LCA 21192+

Loganiceae
Mitreola petiolata (G.F. Gmel.) Torr. & A. Gray, lax hornpod; G-2; O,E (rare)
Mitreola sessilifolia (J.F. Gmel.) G. Don, swamp hornpod; G-1; O (infrequent)

Magnoliaceae
Liriodendron tulipifera L., tuliptree; G-7; E (infrequent)
Magnolia grandiflora L., southern magnolia; J-3; G-9; E (infrequent)

Malvaceae
Callirhoe papaver[1,2] (Cav.) A. Gray, poppy mallow; G-7; E (frequent); LCA 21838+, AKG 9750
Modiola caroliniana (L.) G. Don, Carolina bristlemallow; G-2; O,E (rare – disturbed areas)
Sida elliottii Torr. & A. Gray, Elliott's fanpetals; J-3; E,V (rare); LCA 21373+

Meliaceae
*Melia azedarach** L., chinaberry tree; J-2; O,E (rare)

Myricaceae
Myrica cerifera L., wax myrtle; J-6, G-11; O,E (frequent)

Oleaceae
Chionanthus virginicus L., white fringetree; G-6; O (occasional), E (rare)
Fraxinus americana L., American ash; J-9, G-12; O (rare), E (common)
*Ligustrum japonicum** Thunb., Japanese privet; J-1, G-2; E (rare); LCA 21595+
*Ligustrum lucidum** W.T. Aiton, glossy privet; J-3; G-3; E (infrequent); AFJ 10456+
*Ligustrum sinense** Lour., Chinese privet; J-7, G-3; O,E, (occasional); LCA 11204+

Onagraceae
Gaura filipes Spach, slenderstalk beeblossum; J-6, G-9; O (frequent); AFJ 10279+
*Oenothera speciosa** Nutt., pinkladies; J-3; O (rare); LCA 21903

Orchidaceae
Hexalectris spicata (Walter) Barnhart, crested coralroot; J-1; E,V (rare)
Ponthieva racemosa (Walter) C. Mohr, hairy shadow witch; J-5, G-3; O,E (rare); AKG 6785
Spiranthes odorata (Nutt.) Lindl., fragrant ladiestresses; G-1; E (rare); LCA 21485
Spiranthes ovalis Lindl., October ladiestresses; G-2; E (rare); AFJ 10449
Spiranthes tuberosa Raf., little ladiestresses; J-1; O (rare)

Orobanchaceae

Agalinis obtusifolia Raf., tenlobe false foxglove; J-1, G-3; O (frequent); LCA 20772+, AKG 11077+

Agalinis tenuifolia (Vahl.) Raf., slenderleaf false foxglove; J-6, G-9; O (frequent); LCA 21510+

Aureolaria flava (L.) Farw., smooth yellow false foxglove; G-1; E (frequent)

Buchnera americana L., American bluehearts; J-4, G-2; O (infrequent)

Pedicularis canadensis L., Canadian lousewort; G-3; E,V (occasional)

Oxalidaceae

Oxalis corniculata L., common yellow woodsorrel; J-1, G-4; O (occasional)

Parnassiaceae

Lepuropetalon spathulatum[1,2] Elliott, little people; G-1; O,E (rare); LCA 11090+, AKG 11275

Passifloraceae

Passiflora lutea L., yellow passionflower; J-2, G-3; E (rare)

Plantaginaceae

Mecardonia acuminata (Walter) Small, axilflower; J-7, G-9; O (frequent); AFJ 10286+

Penstemon australis Small, beardtongue; J-1, G-4; O (rare); AKG 7774 (FSU)

Penstemon laevigatus Aiton, eastern smooth beardtongue; G-3, O,E (rare); LCA 21840

Plantago virginica L., Virginia plantain; J-7, G-3; O (frequent); AFJ s.n. (10 May 2005, Brooks-1), AKG 11274

Poaceae

Andropogon gerardii Vitman, big bluestem; G-1; O (rare); AFJ s.n. (17 October 2007, EB East)

Andropogon glomeratus (Walter) Britton et al., bushy bluestem; J-8, G-10; O (occasional); AFJ s.n. (15 November 2007, East Bank Campground)

Andropogon virginicus L., broomsedge bluestem; J-4, G-2; O (infrequent); AFJ s.n. (9 October 2007, Old Car)

Aristida longispica Poir., slimspike threeawn; J-8, G-7; O (common); LCA 21506+, AKG 12080

Aristida oligantha Michx., prairie threeawn; J-5, G-2; O (common); LCA 21447+

Aristida purpurascens Poir., arrowfeather threeawn; J-3, G-3; O (rare); AKG 12079

Aristida stricta Michx. var. *beyrichiana* (Trin.&Rupr.) D.B. Ward, wiregrass; J-1, G-5; O (rare); LCA 21852

Arundinaria gigantea (Walter) Walter ex Muhl., switchcane; G-3; E (rare)

Bouteloua curtipendula (Michx.) Torr., sideoats gramma; G-2; O (rare); RKG 81566, AKG 11464

Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp. *spretum* (Schult.) Freckman & Lelong (FNA 2003 vol. 25), tapered witchgrass; J-1, G-1; O (rare); AFJ 10196+

Dichanthelium bosci (Poir.) Gould & C.A. Clark (FNA 2003 vol. 25), Bosc's witchgrass; J-2, G-1; E (occasional); AFJ 10195

Dichanthelium commutatum (Schult.) Gould (FNA 2003 vol. 25), variable witchgrass; J-5, G-3; O (infrequent); AFJ #10188+

Dichanthelium dichotomum (L.) Gould (FNA 2003 vol. 25), cypress witchgrass; J-5, G-11; O (frequent); AFJ 10289+, AKG 11963

Dichanthelium oligosanthes (Schult.) Gould (FNA 2003 vol. 25), Heller's witchgrass; J-1; E (rare); LCA 21913

Dichanthelium strigosum Muhl. ex Elliott) Freckmann var. *leucoblepharis* (Trin.) Freckmann (FNA 2003 vol. 25), roughhair witchgrass; G-1; O (rare); LCA 21491

Eragrostis elliottii S. Watson, Elliott's lovegrass; J-1, G-7; O (occasional); LCA 21487+

Eragrostis hirsuta (Michx.) Nees, bigtop lovegrass; J-6, G-3; O (infrequent); LCA 21448+

*Eremochloa ophiuroides** (Munro) Hack., centipede grass; J-8, G-5; O (common, disturbed areas); AFJ 10442

Gymnopogon ambiguus (Michx.) Britton et al., bearded skeletongrass; J-2; O,E (rare); LCA 21382

*Imperata cylindrica** (L.) P. Beauv., cogongrass; J-1; O (rare-disturbed areas)

*Lolium arundinaceum** (Schreb.) Darbysh., tall fescue; J-1; E (rare); AFJ 10362 [=*Schedonorus arundinaceus* (Schreb.) Dumort]

Melica mutica Walter, melicgrass; J-1, G-9; O (rare), E (frequent); LCA#21591 FSU

Muhlenbergia capillaris (Lam.) Trin. var. *capillaris*, hairawn muhly; J-7, G-10; O (common); AFJ 10278+

Panicum anceps Michx., beaked panicum; J-6, G-8; O (rare), E (occasional); LCA 21503+

Panicum capillare L., witchgrass; J-3; G-5; O (infrequent); LCA 21490+

Panicum flexile (Gatt.) Scribn., wiry panicgrass; J-6, G-10; O (common); LCA 21449+, AKG 12076

*Paspalum dilatatum** Poir., Dallisgrass; J-1, G-2; O (rare); AFJ 10295+, AKG 11037

Paspalum floridanum Michx., Florida paspalum; J-1, G-1; O,E (rare); AFJ 10491+

*Paspalum urvillei** Steud., Vaseygrass; J-2; O (rare-disturbed areas)

Piptochaetium avenaceum (L.) Parodi, needlegrass; J-3, G-2; E (rare)

Schizachyrium scoparium (Michx.) Nash, little bluestem; J-7, G-10; O (common); LCA 21462+, AKG 11897

Schizachyrium tenerum Nees, slender bluestem; J-2, G-5; O (frequent); AFJ 10280+

Setaria parviflora (Poir.) Kerguelen, yellow bristletail grass; J-9, G-11; O (frequent); LCA 21174+, AKG 10595

Sorghastrum elliottii (C. Mohr) Nash, slender indiangrass; J-3, G-2; O,E (rare); AFJ 10292+

Sorghastrum secundum (Elliott) Nash, lopsided indiangrass; G-4; O,E (rare)

Sphenopholis filiformis (Chapm.) Scribn., longleaf wedgescale; J-1; O (rare); LCA 21590

Sporobolus clandestinus (Biehler) Hitchc. (FNA 2003 vol. 25), hidden dropseed; J-7, G-11; O (common); LCA 21488+

Sporobolus junceus (P. Beauv.) Kunth, pineywoods dropseed; J-8, G-9; O (common); LCA 21446+

Sporobolus vaginiflorus (Torr. ex A. Gray) A.W. Wood, poverty dropseed; J-9, G-7; O (common); LCA 21463+, AKG 9747

Tridens flavus (L.) Hitchc., tall redtop; J-8, G-12; O (rare), E (occasional); AFJ 10444

Polemoniaceae

Phlox divaricata L., wild bluephlox; J-1, G-2; O,E (rare)

Phlox glaberrima L., smooth phlox; J-1, G-3; O,E (rare); AFJ 10208+

Phlox pilosa L., downy phlox; J-8, G-5; O,E (occasional); LCA 21902+, AKG 2827

Polygalaceae

Asemeia grandiflora (Walter) Small (Abbott 2011), showy milkwort; J-6, G-7; O (frequent); LCA 20753+, AKG 9709 (all plants seen on the glades have narrow, linear leaves) [=*Polygala g.* Walter]

Polygala boykinii Nutt., Boykin's milkwort; J-9, G-12; O (frequent); LCA 21284

Primulaceae

Primula meadia[1,2] (L.) A.R. Mast & Reveal, shooting star; G-2; E (frequent); LCA 21857+, AKG 11580

Ranunculaceae

Delphinium carolinianum[1,2] Walter, Carolina larkspur; J-2, G-8; O (infrequent); LCA 21865+, AKG 9813+

Thalictrum revolutum DC., waxyleaf meadowrue; J-1, G-1; E,V (occasional)

Rhamnaceae

Berchemia scandens (Hill) K. Koch, rattan vine; J-6, G-10; O (occasional), E (common); JBN 2741

Rhamnus caroliniana Walter, Carolina buckthorn; J-9, G-4; E (occasional); LCA 21195+

Rosaceae

Agrimonia microcarpa Wallr., smallfruit agrimony; J-2, G-2; E (rare); LCA 21384+

Crataegus pulcherrima Ashe (Nelson 2011), beautiful hawthorn; G-5; E (infrequent); AFJ 10512+

Crataegus spathulata Michx., littlehip hawthorn; G-5; E (common); AFJ 10452

Fragaria virginiana Duchesne, Virginia strawberry; J-3; E (rare); LCA 21206

Malus angustifolia (Aiton) Michx., southern crabapple; G-3; E (rare)

Prunus angustifolia Marshall, chickasaw plum; G-1; O (rare); AFJ 10516

Prunus caroliniana (Mill.) Aiton, Carolina laurelcherry; G-1; O (rare)

Prunus serotina Ehrh., black cherry; J-2, G-4; E (infrequent)

*Pyracantha koidzumii** (Hyata) Rehder, Formosa firethorn; J-4, G-3; O,E (occasional to frequent); AFJ#10487 FSU+

Rosa carolina L., Carolina rose; J-3, G-3; O,E (infrequent)

Rubus trivialis Michx., southern dewberry; J-1, G-2; O,E (occasional)

Rubiaceae

Diodia teres Walter, poor joe; J-3; O,E (infrequent)

Diodia virginiana L., Virginia buttonweed; J-3; O (infrequent)

Galium circaezans Michx., forest bedstraw; J-2; O (rare); LCA 20776+

Galium pilosum Aiton, hairy bedstraw; J-2; O (rare)

Stenaria nigricans (Lam.) Terrell, diamondflowers; J-9, G-11; O (common); LCA 21507+, AKG 9748

Rutaceae

Ptelea trifoliata L., wafer ash; J-1, G-5; O,E (occasional), LCA 9196

Zanthoxylum clava-herculis L., Hercules club; G-1; E,V (rare)

Sapindaceae

Acer rubrum L., red maple; G-2; E (rare)

Acer saccharum Marshall ssp. *floridanum* (Chapm.) Desmarais, Florida maple; J-1, G-12; E (common)

Aesculus pavia L., red buckeye; J-2, G-4; E (occasional)

Sapotaceae

Sideroxylon lanuginosum Michx., gum bully; J-8, G-3; E (common)

Sideroxylon reclinatum Michx., Florida bully; J-2, G-11; O (frequent), E (common)

Smilacaceae

Smilax bona-nox L., saw greenbrier; J-4, G-2; O (infrequent)

Smilax smallii Morong, Jackson vine; J-1, G-4; O (rare)

Smilax tamnoides L., bristly greenbrier; J-2; E (rare)

Solanaceae

Solanum carolinense L. Carolina horsenettle; J-1, G-1; O (rare)

Strychnaceae

Spigelia marilandica (L.) L., woodland pinkroot; G-9; O (rare), E (frequent)

Turneraceae

Piriqueta cistoides (L.) Griseb.ssp. *caroliniana* (Walter) Arbo, pitted stripeseed; G-10; O (frequent); LCA 21851

Ulmaceae

Ulmus alata Michx., winged elm; G-10; O (rare), E (common); JBN 2724

Ulmus rubra Muhl., slippery elm; J-1, G-3; E (rare); JBN 2753

Verbenaceae

Glandularia canadensis (L.) Small, rose mock vervain; J-2; E (rare-disturbed areas); RKG 80403

*Glandularia pulchella** (Sweet) Tronc., moss verbena; J-1,G-2; O (rare-disturbed areas)

*Verbena brasiliensis** Vell., Brazilian vervain; J-2, G-2; O (rare)

*Verbena rigida** Spreng., tuberous vervain; J-2, G-1; O (rare); LCA 21180

Violaceae

Viola palmata L., early blue violet; G-1; E (rare)

Viola sororia Willd., common blue violet; J-5, G-3; O,E (rare)

Viola walteri House, Walter's violet; J-2, G-7; O,E (infrequent)

Vitaceae

Ampelopsis arborea (L.) Koehne, peppervine; J-2, G-3; O,E (infrequent)

Parthenocissus quinquefolia (L.) Planch., Virginia creeper; J-5, G-2; O,E (occasional)

Vitis rotundifolia Michx., muscadine; J-1, G-4; O,E (occasional)

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HISTORY, DISPERSAL, AND DISTRIBUTION OF *BUDDLEJA DAVIDII* (SCROPHULARIACEAE) IN KENTUCKY

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ABSTRACT

Buddleja davidii Franch. (Scrophulariaceae), orange-eye butterfly bush, an introduced ornamental shrub from China, is reported with documentation as unequivocally naturalized in Kentucky for the first time. It was first documented outside of horticultural cultivation with voucher specimens from Pike County (1960 and 1982), Calloway County (2003), Greenup County (2010), Powell County (2011), and Laurel County (2012). A discussion of *Buddleja davidii* in Kentucky concludes with a diagnostic description from recent Laurel County specimens.

KEY WORDS: *Buddleja davidii*, Buddlejaceae, dispersal, distribution, Kentucky, naturalized, orange-eye butterfly bush, Scrophulariaceae, summer lilac

RESUMEN

Buddleja davidii Franch. (Scrophulariaceae), Arbusto de las mariposas de ojo naranja, un arbusto ornamental introducido de la China, se reporta por primera vez con documentación como planta inequívocamente naturalizada en Kentucky. Se documenta por primera vez fuera de un lugar de cultivo hortícola con muestras testigo del condado de Pike (1960 y 1982), condado de Calloway (2003), condado de Greenup (2010), condado de Powell (2011) y condado de Laurel (2012). Una discusión de *Buddleja davidii* en Kentucky concluye con una descripción diagnóstica de muestras recientes del condado de Laurel.

INTRODUCTION

The genus *Buddleja* was named by Linnaeus (1753, 1754) to commemorate the English botanist and clergyman Adam Buddle (1660–1715). A New World specimen of *B. americana* from the Caribbean was brought to Linnaeus in the 1730s by Dr. William Houstoun (Stuart 2006; Dirr 2009). *Buddleja* is a cosmopolitan group of some 90–100 species of which many of the Asiatic taxa have been grown as ornamentals in arboreta, botanical gardens, landscape gardens, nurseries, parks, garden clubs, and yards (Stuart 2006; Dirr 2009). The centers of diversity for *Buddleja* are South Africa and Chinese-Himalayan Asia in the Old World (Leeuwenberg 1979; Stuart 2006; Tallent-Halsell & Watt 2009) and South America, Central America, and southwestern United States in the New World (Norman 2000; Tallent-Halsell & Watt 2009).

Buddleja davidii Franch. (Scrophulariaceae), summer lilac or orange-eye butterfly bush (Bailey & Bailey 1976; Norman 2012), are unarmed, multi-stemmed Chinese deciduous to semideciduous shrubs up to 5.0 m tall and a spread of 6.5 m. *Buddleja davidii* gained its specific epithet, *davidii*, by Franchet (1888) to honor Père Armand David (1826–1900), a French Jesuit missionary and naturalist in eastern Tibet, who introduced the first *B. davidii* to Adrian René Franchet (1834–1900) at the Paris Museum of Natural History (Stuart 2006; Tallent-Halsell & Watt 2009).

It was introduced from China by the English plant collector, E.H. Wilson into the Royal Botanic Garden, Kew, England, in 1896, and then at the Arnold Arboretum, Harvard University, around 1900 (Stuart 2006; Tallent-Halsell & Watt 2009). Orange-eye butterfly bush is native to 13 provinces of central and southwestern China and has been introduced into Japan (Zheng-Yi & Raven 1996; Stuart 2006). The 13 Chinese provinces are mapped by Zheng et al. (2006) and Tallent-Halsell & Watt (2009).

Buddleja davidii has been variously placed by recent workers in the Loganiaceae, Buddlejaceae, and most recently in the Scrophulariaceae (IPNI 2005; Norman 2012; Tropicos 2012; USDA, ARS 2012a; Weakley 2012).

Buddleja certainly has strong affinities within the Scrophulariaceae in the order Lamiales based on current molecular systematics. Nomenclature for all taxa in this article follows Weakley (2012).

Buddleja davidii is the most widely cultivated species grown especially for its attractive dark green and grayish-white pubescent foliage, flowers which vary from colorful lilac-rose to lilac-lavender, lilac-blue, red-violet, purple to white, pleasant fragrance, and a high nectar content for the attraction of butterflies, moths, bees, wasps, and birds (Norman 2000; Stuart 2006; Dirr 2009; Tallent-Halsell & Watt 2009). *Buddleja davidii* has over 150 cultivars and hybrids recognized to date (see: Leeuwenberg 1979; Stuart 2006; Dirr 2009). A vigorous, cold hardy ornamental shrub, it is well adapted to USDA hardiness zones 5–9 (Stuart 2006; Dirr 2009). In Kentucky, *B. davidii* grows well in zone 6 (-10 to 0°F [-20.6 to 17.8°C]) within the United States Hardiness Zone Map (USDA, ARS 2012b).

We report *Buddleja davidii* as unequivocally naturalized in Kentucky for the first time with documentation based on recent plant collections, examination of herbarium specimens, data from plant collector's log notebooks, and a Kentucky literature survey. Our research indicates *B. davidii* has non-introduced populations established in five counties during the last 30 year period.

DISCUSSION

Buddleja davidii is currently naturalized (*sensu lato*), i.e., growing without cultivation, in Australia, Europe, Fiji, and New Zealand in the Eastern Hemisphere and in Canada, Central America, Puerto Rico, South America, and the United States in the Western Hemisphere (Tallent-Halsell & Watt 2009; Norman 2012). Tallent-Halsell and Watt (2009) mapped 20 states of the USA and the Canadian Provinces of British Columbia and Ontario. The USDA, NCRS (2012) mapped the same USA distributions, but deleted Alabama and added Illinois. In the conterminous United States, Kartesz (2011) included the District of Columbia, Delaware, Indiana, Kansas, and Rhode Island in addition to the above 21 states in his Biota of North America Program (BONAP). The USDA, FS (2012) mapped the combined distributions in the United States of Kartesz (2011), Tallent-Halsell and Webb (2009), and the USDA, NRCS (2012), but also included Arizona, Arkansas, Louisiana, Mississippi, Nevada, New Mexico, Texas, and Utah. Tropicos (2012) included Missouri based on voucher specimens (*G. Yatskievych & K. Yatskievych 02-62*; *T.E. Smith 3832*) deposited at the Missouri Botanical Garden Herbarium (MO). The overall distribution of *B. davidii* in the United States and Canada from these five distribution sources totals 34 states (including Hawaii), as well as the District of Columbia, the territory of Puerto Rico, and the Canadian Provinces of British Columbia and Ontario.

The above distribution sources do not specify whether the non-native status of *Buddleja davidii* in the United States (e.g. in Kentucky) is cultivated, introduced, persisting, adventive, or naturalized according to the definitions by Nesom (2000). In essence, these map distribution sources probably represent a combination of all those non-native classification categories from literature reports and herbarium vouchers.

Common temperate habitats for *Buddleja davidii* growing without cultivation in the United States include railroad lines, limestone quarries, coal surface-mined lands, abandoned cultivated areas, urban disturbed areas, successional woodland edges, roadsides, riparian corridors, streambeds, floodplains, and sandy lake shores, among many others (Tallent-Halsell & Watt 2009; Norman 2012). Orange-eye butterfly bush plainly has a broad ecological amplitude, which favors colonization, establishment, and naturalization in a diversity of open, insolated and weedy disturbed habitats.

As with numerous woody plants, *Buddleja davidii* has also become invasive in several countries where it has been naturalized, e.g., Australia, England, France, New Zealand, and Hawaii, Oregon, and Washington in the USA (Tallent-Halsell & Watt 2009; USDA, ARS 2012a; Young-Mathews 2011; Norman 2012). *Buddleja davidii* was listed as one of the invasive Asian plants established in the United States by Zheng et. al. (2006). In Oregon, *B. davidii* is classified as a "B" designated noxious weed subject to quarantine, and in Washington it is listed as a Class "C" noxious weed (Tallent-Halsell & Watt 2009; Young-Mathews 2011; USDA, NRCS 2012). Tallent-Halsell and Watt (2009) have provided the most comprehensive discussion on the biology, distribution, ecology, and invasiveness of *Buddleja davidii*.

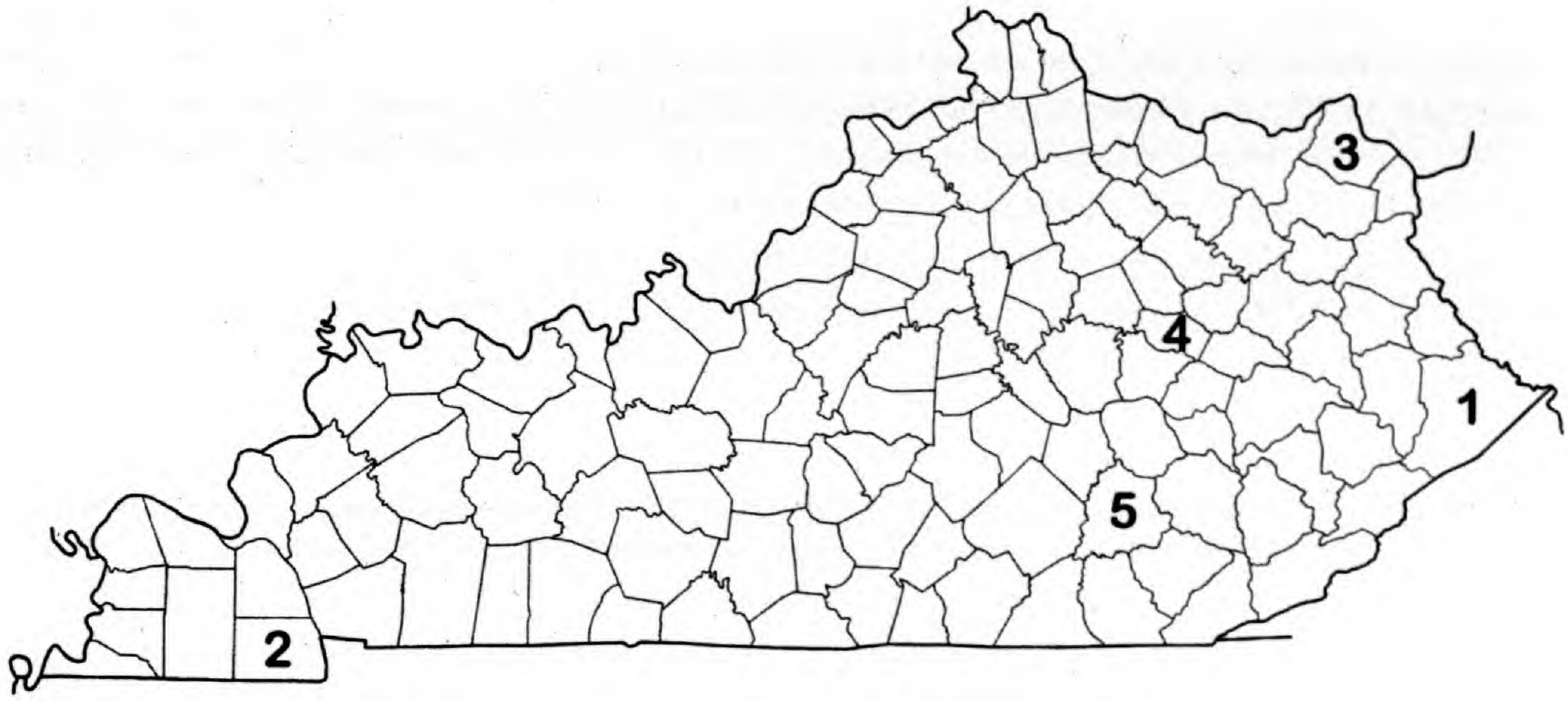


Fig. 1. Kentucky counties with naturalized *Buddleja davidii*: 1=Pike (1960 & 1982), 2=Calloway (2003), 3=Greenup (2010), 4=Powell (2011), 5=Laurel (2012).

Kentucky Literature and *Buddleja davidii* in Pike County

The ascription of this species to the flora of Kentucky warrants a discussion of previous Kentucky literature accounts. *Buddleja davidii* was credited as established in Kentucky by Medley (1993) and state-mapped by the USDA, NRCS (2012), and other workers (e.g., Kartesz 2011; USDA, FS 2012; USDA, ARS 2012a). Tallent-Halsell and Webb (2009) used these distribution resources and further based naturalization of *B. davidii* in their North America map on being "escaped from cultivation." However, their reported Kentucky distribution was founded in part on the misapplication of *Buddleja alternifolia*, which was planted at the Bernheim Forest and Arboretum (see: Gunn 1959).

Browne and Athey (1992) in their *Vascular Plants of Kentucky: an Annotated Checklist*, did not list *Buddleja davidii*. Likewise, Jones (2005) in the *Plant Life of Kentucky* did not include *B. davidii* (Buddlejaceae) as part of the Kentucky flora, but noted it was "to be expected as an escape in Kentucky." Clark and Weckman (2008) did not discuss or map *B. davidii* in their *Annotated Catalog and Atlas of Kentucky Woody Plants*.

The first *Buddleja davidii* specimen in a Kentucky herbarium was a cultivated plant collected in Fayette County in Lexington at the University of Kentucky Agricultural Experiment Station, 24 Aug 1923, *H. Garman s.n.* (BEREA, UK). The first report of a potentially escaped, non-cultivated orange-eye butterfly bush for Kentucky is a Pike County voucher (Fig. 1) from 1960 on file at the University of Kentucky Herbarium (UK); but, this specimen was not referenced by Medley (1993). The label data is:

KENTUCKY. Pike Co.: Cedar Street near Chloe Creek, 15 Oct 1960, *Mary Louise Miniard 42* (UK)!

Medley (1993) in his dissertation, *An Annotated Catalog of the Known and Reported Vascular Flora of Kentucky*, reported *Buddleja davidii* Franch. (Buddlejaceae) as "Rarely established along railroads and in disturbed areas in at least two localities in Pike County on the Allegheny Plateau." His two specimens from Pike County, *Medley & Levy 5895-82* and *6364-82* (DHL) were eventually transferred to the Western Kentucky University Herbarium (WKU). However, these unmounted specimens were not available for study by us since they have not yet been incorporated into WKU from the Davies Herbarium (DHL) of the University of Louisville. Fortunately, Medley's original 1982 collection log notebook was available at WKU and the relevant data (pp. 175–182) are:

KENTUCKY. Pike Co.: Pikeville 7-5 minute Quadrangle, Pikeville, spontaneous along abandoned railroad track in SW part of town, associates: *Chaenorhinum minus*, *Desmodium* spp., *Eupatorium* sp., *Ipomoea lacunosa*, *Oenothera biennis*, and *Sonchus asper*, 16 Aug 1982, *Max E. Medley & Foster Levy 6364-82* (DHL).

The 1982 collection label data from the two disturbed areas noted by Medley (1993) from Pike County are noteworthy: In Pikeville, Medley (*5895-82*) collected *Buddleja davidii* at McDonald's Restaurant, while Levy *s.n.* collected a specimen at Wendy's Restaurant, each with the same three botanists, but with different dates and restaurants. Medley's collection data were gathered from his collection log notebook, and Levy's specimen was examined at the University of North Carolina Herbarium (NCU) at Chapel Hill:

KENTUCKY. Pike Co.: Pikeville, spontaneous behind McDonald's in weedy area, 8 Aug 1982, *Max E. Medley 5895-82, with John W. Thieret and Foster Levy* (DHL); Flora of Pike County, Pikeville, behind Wendy's in a rock pile, 18 Aug 1982, *Foster Levy s.n., with John W. Thieret and Max E. Medley* (NCU)!

Campbell and Medley (2012) in their *Atlas of Vascular Plants in Kentucky* on *Buddleja davidii* Franch. (Buddlejaceae) stated, "Although widely cultivated (as "butterfly bush"), there are few reports of this Chinese shrub escaping in eastern North America." Campbell and Medley noted that *B. davidii* may be increasing in Appalachian regions in the southeastern states and referred to the Pike County collection data from Medley (1993). Campbell's incidental collection of a seedling at a woods edge on a sandy ridge in Pulaski County, was not found in any Kentucky herbarium. Regardless of their discussion, Campbell and Medley (2012) did not map *B. davidii* in their Kentucky vascular plant atlas.

Buddleja davidii in Calloway County

In Calloway County (Fig. 1), during the summer 2003, two flowering specimens of *Buddleja davidii* were collected (*Thompson 03-389*) in Quaternary Ochlockonee alluvial gravelly loam soils along a roadside ditch thicket near the southernmost boundary of Hancock Biological Station on Kentucky Lake. The vouchers were deposited in the Berea College Herbarium (BEREA) and Murray State University Herbarium (MUR). The mature shrub was treated as a non-cultivated escape since there were no homesteads or building remains anywhere within its vicinity, nor was it close to any populated area. The nearby Pacer Point Marina, an asphalt boat ramp landing, was not likely a source for the plant. Exact label data from this Calloway County site are:

KENTUCKY: Calloway Co.: Pacer Point Marina area, 0.8 mi E from jct. of Lancaster Road to Watersport Road, and 0.5 mi S on Watersport Road to ditch thicket near sandy beach, introduced shrub from China, 2–3 m with lilac salverform flowers with an orange center, rare, 24 Jun 2003, *R.L. Thompson 03-389* (BEREA, MUR)

Buddleja davidii in Greenup County

Orange-eye butterfly bush was collected in Greenup County (Fig. 1) on a roadside along a creek near a residential area in 2010, but without a town or city listed on the label data. It is not known if the shrub was from a cultivated or non-cultivated plant, although it may well have been an escaped plant. The label data from this specimen at Morehead State University Herbarium (MDKY) are:

KENTUCKY. Greenup Co.: roadside at end of creek with much *Quercus* and *Ambrosia*, elev. 617 ft, near residential area, 38°26'24"N and 83°41'25"W, 4 Oct 2010, *Steffany Seagraves 31* (MDKY)!

Buddleja davidii in Powell County

David Taylor, USDAFS botanist, discovered a volunteering *Buddleja davidii* shrub in Powell County (Fig. 1) during the summer 2011 in the Daniel Boone National Forest within the Red River Gorge on Alticrest-Ramsey-Rock Outcrop complex soils over Pennsylvanian-aged Lee Formation conglomeratic sandstone. The plant was found during a reconnaissance of an area severely burned in the fall of 2010. The wildfire burned organic matter to mineral soil and killed most overstory, midstory and understory trees, and 50-60% of the shrubs. At the time of collection, bare mineral soil accounted for 60–70% of the surface cover (D.D. Taylor pers. comm. 2012). Data from his specimen, "On Permanent Loan From USDA Forest Service," are as follows:

KENTUCKY. Powell Co.: Daniel Boone National Forest, Red River Gorge, lat. 37.825827, long. -83.678275, elev. 1220 ft asl, in moist soil ca. 60 ft W of Auxier Ridge trail, ca. 250 air ft S of jct. with Court House Rock Trail, with *Tussilago farfara*, *Paulownia tomentosa*, *Sonchus asper*, *Eupatorium serotinum*, *Dichanthelium commutatum* subsp. *ashei*, and *Marchantia polymorpha*, 24 Aug 2011, *David D. Taylor 18772* (BEREA).

Establishment and Dispersal of *Buddleja davidii* in Laurel County

The most recent Kentucky collections of *Buddleja davidii* were from three local sites of Laurel County (Fig. 1)



FIG. 2. Habitat of *Buddleja davidii* by CSX Railway tracks at concrete culvert in London, Laurel County, Kentucky, September 10, 2012.

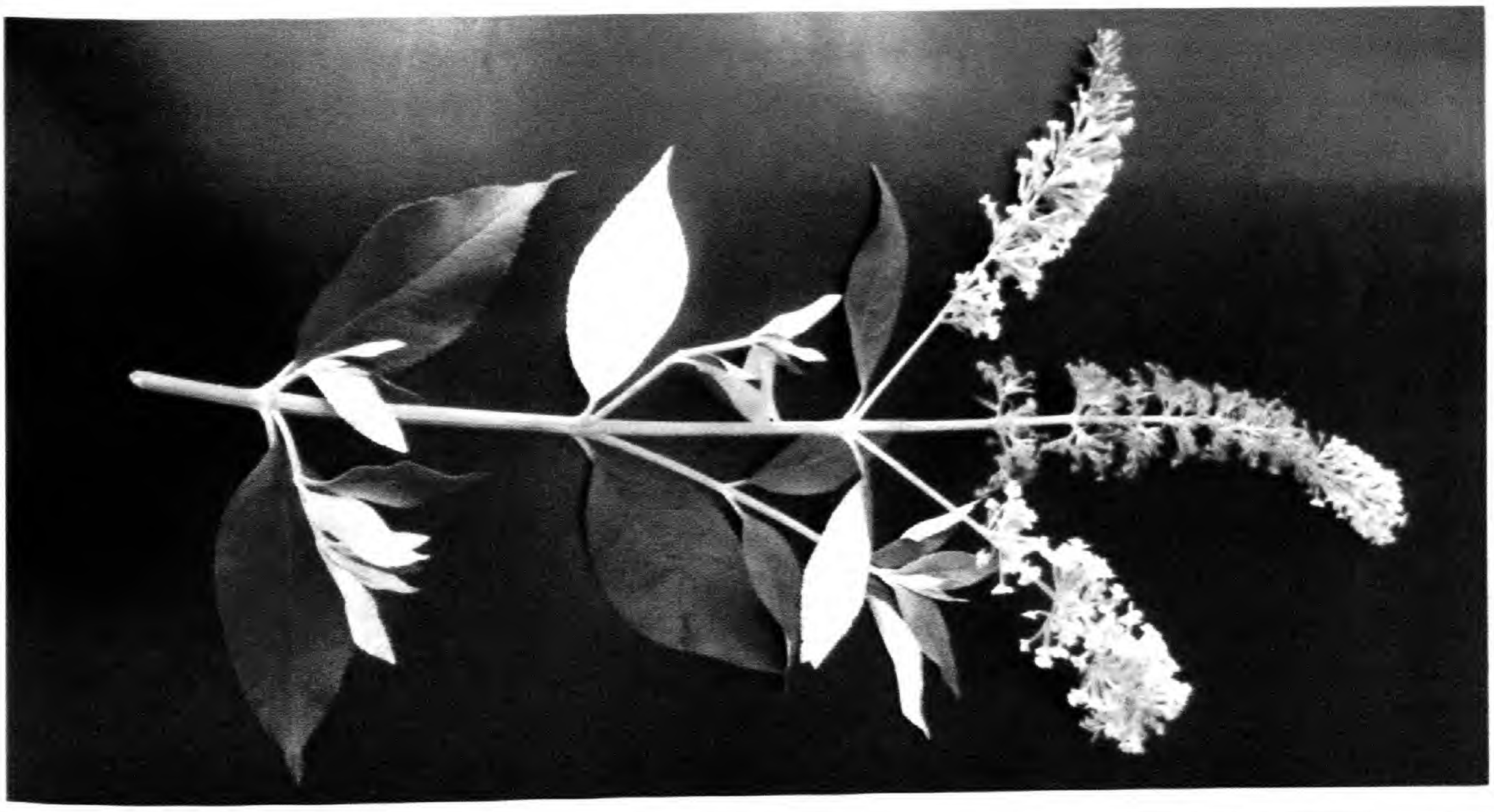


FIG. 3. Flowering branchlet of *Buddleja davidii* (*R.L. Thompson 12-1090*, BEREA).

during September and November 2012. While on a September 4th collecting trip towards a vascular flora of Laurel County, we discovered a non-cultivated *B. davidii* established along the CSX Railway in the city of London and voucher specimens were deposited in BEREA and the Missouri Botanical Garden Herbarium (MO). A single established orange-eye butterfly bush 1.5 m high with a cymose panicle of lilac-colored flowers with orange-eyed throats was present and appeared locally naturalized at this site. A second collecting trip to the general site on September 10th revealed another flowering individual a short distance away from the first collection site. On November 4th, a third trip was made to collect fruits from the two previous colonies at which time three additional fruiting shrubs and four scattered seedlings were discovered on the east side of the CSX railroad right-of-way, ca. 100 m south from either of the two previous plant sites. Representative voucher specimens were taken from the populations of the second and third trips and placed on file in BEREA, MO, and NCU. Duplicate specimens from the collecting trips have been distributed to other herbaria as designated by herbarium acronyms from Thiers (2012).

Our collection label data of *Buddleja davidii* from these three reconnaissance trips to the CSX Railway in London, Laurel County, are summarized below:

KENTUCKY. Laurel Co.: London Quadrangle, London, East 4th Street (KY 80) E of Flowers Bakery (501 E. 4th St.) and 2.0 m W of the CSX railroad tracks in granite aggregate at a concrete culvert by a drainage ditch just W of jct. KY 354N (Tobacco Road) and KY 80, elev. 358 m, lat. 37.116908, long. -84.066789, 4 Sep 2012, *R.L. Thompson & J.R. Abbott 12-1072* (BEREA, MO); 10 Sep 2012, *R.L. Thompson 12-1090* (BEREA, MO, NCU); 4 Nov 2012, *R.L. Thompson & K. Rivers Thompson 12-1137* (BEREA, BRIT, EKY, KNK, MDKY, MO, MUR, NCU, UK); *R.L. Thompson & Katrina Rivers Thompson 12-1141* (BEREA, MO, NCU).

Characteristic associates growing in the granite, gneiss, and limestone railroad aggregate ballast were *Ambrosia artemisiifolia, Cichorium intybus, Conyza canadensis, Digitaria sanguinalis, Euphorbia maculata, E. nutans, Ipomoea coccinea, Kummerowia striata, Lathyrus latifolius, Oenothera biennis, Sonchus asper, Symphyotrichum pilosum,* and *Trifolium repens*. Some associated plants at the ditch margin included *Acer negundo, A. rubrum, A. saccharinum, Ambrosia trifida, Catalpa speciosa, Echinochloa muricata, Eupatorium serotinum,* and *Paspalum dilatatum*.

KENTUCKY. Laurel Co.: London Quadrangle, London, East 4th Street (KY 80) S of Flowers Bakery and 4.0 m S 2.0 m W of the CSX railroad tracks adjacent to Railroad Street, elev. 359 m, lat. 37.116905, long. -84.066788, flowering shrub severely cut back, although not herbicide-sprayed, 10 Sep 2012, *R.L. Thompson 12-1097* (BEREA, MO); 4 Nov 2012, *R.L. Thompson & K. Rivers Thompson 12-1138* (BEREA, BRIT, MO, NCU).

This orange-eye butterfly bush represents a second non-cultivated individual 16 m diagonally across from the shrub at the concrete culvert, probably from a seed source spread by trains. Ruderal associated species observed around *Buddleja davidii* in the railway aggregate between KY 80 and Railroad Street were *Ambrosia artemisiifolia, Conyza canadensis, Daucus carota, Digitaria sanguinalis, Echinochloa crusgalli, Eleusine indica, Eragrostis pectinacea, Eupatorium serotinum, Euphorbia dentata, E. maculata, E. nutans, Kummerowia striata, Lespedeza cuneata, Polygonum aviculare, Setaria pumila, Solidago altissima, Symphyotrichum pilosum,* and *Verbascum thapsus*.

KENTUCKY. Laurel Co.: London Quadrangle, London, S of KY 354N, across East 4th Street (KY 80) S 120 m down to 216 McLemore Street on E side of CSX Railroad right-of-way and grassy street margin, elev. 357 m, lat. 37.116880, long. -84.066782, 04 Nov 2012, *R.L. Thompson & K. Rivers Thompson 12-1140* (BEREA, BRIT, EKY, KNK, MDKY, MO, MUR, NCU, TENN, UK).

This third collection corroborates further evidence for the naturalization of *Buddleja davidii*, as three additional fruiting shrubs and four seedlings were scattered for 35 m along the east side of the railroad right-of-way. A personal account from a local resident (C. House, pers. comm. 2012) noted several seedlings had become established at the edge of his yard at 216 McLemore Street and the ballast of the railroad bed during the last 2 or 3 years. He remarked "this area hasn't been [herbicide] sprayed and those three shrubs first appeared 3 or 4 years ago."

Only 12 depauperate associates were identified at this grassy habitat due to recent heavy fall frosts. Exotic and native herbaceous taxa in this habitat were *Amaranthus hybridus, Andropogon virginicus, Conyza canadensis, Croton monanthogynus, Cynodon dactylon, Digitaria sanguinalis, Euphorbia nutans, Lamium amplexicaule, L. purpureum, Muhlenbergia schreberi, Schedonorus arundinaceus,* and *Setaria pumila*.

Buddleja davidii Naturalized in Kentucky

We have classified *Buddleja davidii* as clearly naturalized for the first time in Kentucky based on our interpretation of the "naturalized" category of Nesom (2000): a non-native plant population introduced into the flora from other introduced populations, which are spreading or dispersing from year to year without deliberate anthropogenic assistance.

The data from voucher specimens in Pike, Calloway, and Greenup counties indicate the naturalization of *B. davidii* in Kentucky over the last 30 years. Even if the species were originally introduced into these three counties, their habitat locations would infer otherwise and they would still provide potential diaspore sources into other non-cultivated areas. The 2011 Powell County collection of a volunteering, established non-introduced *B. davidii* validates naturalization in Kentucky. In Laurel County, the five new non-introduced shrubs and seedlings growing without cultivation within the railroad right-of-way habitats of London provide conclusive evidence of naturalization of orange-eye butterfly bush in Kentucky. Nevertheless, the naturalization of *B. davidii* in Kentucky at this time clearly does not imply classification of it as an "invasive species" based on classification standard criteria from the KY-EPPC (2012).

The most prudent explanation of plant propagule spread for this population of *Buddleja davidii* is the phenomenon of "slipstreaming," the low pressure drag and blowing of scattered diaspores caused by methods of moving transportation (Eskridge & Hunt 1979; Garnier et al. 2008; von der Lippe et al. 2013). The numerous, minute, winged wind-dispersed seeds of *Buddleja davidii* could have been easily scattered in the slipstreaming wake of railway train locomotives and freight boxcars.

Dispersal Mechanism by Railways

Although *Buddleja davidii* populations in North America are not restricted to active or abandoned railroad habitats, we consider these three established colonies of *B. davidii* in Laurel County, Kentucky, to have been naturalized through the dispersal of propagules by the CSX Railway.

Railways have played an important role in providing suitable habitats and dispersal means of vascular plants. Slipstreaming along railroads has been verified as a means for the rapid dissemination of non-native fruits and seeds in the United States from literature reports and herbarium vouchers, e.g., *Chaenorhinum minus* (Plantaginaceae s.l.). The seeds of this naturalized European annual have been effectively and rapidly dispersed by the action of railway trains and their linked boxcars (Arnold 1979, 1981, 1991; Widrlechner 1982; Sauer 1988). Railroad rights-of-ways have been correlated with numerous exotic weedy invaders in Illinois, Missouri, and Kentucky (Thompson & Heineke 1977; Thompson 1979; Cranfill & Thieret 1981; Medley et al. 1983; Thieret & Thompson 1984).

Four examples from the literature and herbarium specimens illustrate the occurrence of railroad transportation of wind-dispersed seeds and establishment specifically for *Buddleja davidii*. Miller (1984) in his dissertation reported that *B. davidii* had been originally spread throughout Great Britain along railroad tracks by being carried on freight cars and through train slipstreaming.

Mühlenbach (1979) related the slipstream dragging effect by trains in St. Louis railroad yards and the addition of aggregate ballast as two means of dispersing propagules of herbaceous and woody plants, including *Buddleia davidii*, as documented by:

MISSOURI. St. Louis Co.: collections from Railroad Sites: St. Louis Union Station on track 9, one big specimen, about 5 ft apart from a *Fragaria* sp. colony of huge size, not planted, determined by E. Norman, 18 Jul 1971, *V. Mühlenbach 3622* (MO)!

Radford et al. (1968) in the *Manual of the Vascular Flora of the Carolinas* similarly reported *Buddleja davidii* as a rare introduction along a railroad in North Carolina. Label data from NCU confirms that information:

NORTH CAROLINA. Haywood Co.: cinder bed along railroad, 1.9 mi E of Canton, US 19-23, 15 Jul 1958, *Harry E. Ahles & J.A. Duke 46516* (NCU)!

In Knoxville, Knox County, Tennessee, an escaped population of *Buddleja davidii* was documented on November 21, 2012, along a railroad bed adjacent to Mead's Quarry Lake, a part of the Ijams Nature Center. This population was discovered from information given by Dr. Dwayne Estes, Austin Peay State University Herbarium



Fig. 4. Inflorescence and flowers of *Buddleja davidii* (*Thompson 12-1090*, BEREA).



Fig. 5. Infructescence and seed capsules of *Buddleja davidii* (*Thompson & Rivers Thompson 12-1140*, BEREA).

(APSC) curator, who discovered the *B. davidii* population in 2003 (D. Estes, pers. comm. 2012).

Many mature shrubs as well as smaller volunteering shrubs and seedlings have colonized a 75 m extension of a railroad bed to the SSE of the three demolished limestone kilns. Orange-eye butterfly bush is locally naturalized at this Tennessee site, which provides evidence on the concept of wind-dispersed seeds being spread and established shrub populations being created through the slipstreaming action of active trains. This railway quarry site data are:

TENNESSEE. Knox Co.: Knoxville, Mead's Quarry Lake of the Ijams Nature Center, elev. 269 m, lat. 35.950533, long. -83.867525, several established shrubs between the limestone kiln wall and along the railroad track bed in agricultural lime slag spoils, frequent in abundance, 20 Nov 2012, *R.L. Thompson & K. Rivers Thompson 12-1153* (APSC, BEREA, MO, NCU, TENN).

Representative herbaceous associates with *Buddleja davidii* included *Ambrosia artemisiifolia, Andropogon virginicus, Conyza canadensis, Croton monanthogynus, Daucus carota, Lespedeza cuneata, Panicum flexile, Polymnia canadensis, Schedonorus arundinaceus, Solidago altissima, Sorghum halepense,* and *Symphyotrichum pilosum,* among several others. Characteristic woody taxa between the railway tracks and kilns were *Acer negundo, Ailanthus atissima, Celtis occidentalis, Juniperus virginiana, Ligustrum sinense, Lonicera japonica, L. maackii, Platanus occidentalis, Rhus glabra, Robinia pseudoacacia, Rubus occidentalis, Pyrus calleryana,* and *Rosa multiflora.*

Diagnostic Description of Laurel County *Buddleja davidii* Specimens

The diagnostic description of *Buddleja davidii* here provides the first baseline taxonomic description directly from Kentucky material. It is notably modeled after the excellent species descriptions of Norman (2000, 2012).

Measurements were made of 33 living branches from the three Laurel County habitats prior to preparation as herbarium specimens. Measurements of flowers, fruits, and seeds were made with the use of a 5 mm Micro-Scale™ and a 10 mm Micro-Scale™ Micro-Tools from Electron Microscopy Sciences, Hatfield, Pennsylvania, in combination with a Bausch & Lomb StereoZoom 4 Microscope™.

Shrubs deciduous, unarmed, multi-stemmed, 1.2–2.2 m tall, 1.0–1.8 m spread, older branchlets greenish brown to brown, sparse stellate-tomentose to glabrescent; young branchlets tetragonous, densely grayish white canescent to stellate-glandular tomentose (Fig. 2). **Leaves** opposite, simple, pinnate, 10–15 lateral veins, blade narrowly to broadly elliptic-lanceolate to lanceolate-ovate 6.0–13.0 × 1.5–5.5 cm, dark forest green and glabrous adaxially, white stellate-tomentose abaxially, apex sharply acute, base cuneate-attenuate, margin serrate, new lateral leaf flushes white-canescent; petiole 5.0–10.0 mm, stipules, narrow auriculate, 1.0–2.0 mm high, forming prominent stem lines adjoining leaf bases (Fig. 3). **Inflorescences** terminal, indeterminate thyrsoid cymes, tapered and secund, 10.0–36.0 × 3.0–5.5 cm, often with two lateral branches, pseudoverticel cymes, 15–30 pairs each with 3–20 flowers, peduncles 5.0–15.0 mm (Fig. 3). **Flowers** numerous, perfect, 4-merous. Calyx campanulate, sessile to pedicillate 1.0 mm, persistent, greenish to red-purple, tube 2.4–3.1 × 1.0–1.6 mm, stellate and glandular outside, glabrous inside; lobes acute, 0.8–1.5 mm. Corolla salverform, lilac-rose, lilac-lavender, lilac-blue to red-purple, tube subcylindrical 8.0–12.0 × 1.0–1.2 mm, glabrous to sparsely stellate outside, pilose inside, lobes suborbicular to spatulate, 2.0–3.0 mm, glabrous, margin crenate-serrate, limb, 7.0–9.0 mm with a narrow white to yellow ring around an orange circle (eye) extending 1.0–1.5 mm into throat. Stamens 4, sessile, anthers dorsifixed, 1.0–1.2 mm, inserted at or near the middle of the pilose corolla tube. Ovary superior, ovoid, glabrous, syncarpous bicarpellate, 2.0–3.0 × 0.9–1.1 mm, placentation axile, stigma clavate, 1.5–2.0 × 0.8–1.3 mm (Fig. 4). **Capsules** septicidal, two-valved dehiscence, light olive green to brown at maturity, narrowly linear-oblong to elliptic, 9.0–15.0 × 1.8–2.3 mm (Fig. 5). **Seeds** 30–40, linear-fusiform, long-winged, 4.0–5.3 × 0.4–0.5 mm, dark brown, dorsiventrally compressed, wings translucent tan-brown, tapered at both ends, 1.7–2.1 mm (Fig. 5).

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JOURNAL NOTICE

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ASTROLEPIS SINUATA (PTERIDACEAE) NEW TO THE FLORA OF LOUISIANA

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ABSTRACT

Astrolepis sinuata is reported new for the flora of Louisiana.

RESUMEN

Astrolepis sinuata se cita como nueva para la flora de Luisiana.

A recent collection of *Astrolepis sinuata* (Lag. ex Sw.) Benham and Windham from southwestern Louisiana is apparently the first for the state. This species is not listed for Louisiana by Thieret (1980), Neyland (2011), Benham and Windham (1993), Thomas and Allen (1993), or the USDA NRCS (2012). It is reported from Arizona, New Mexico, and western and central Texas. There the range extends eastward to Comal and Anderson counties (Diggs et al. 2006; Diggs & Lipscomb 2013), into Austin County (Diggs & Lipscomb 2013) and also to Ellis County (USDA NRCS 2012). A disjunct population is reported from Meriwether County, Georgia (Benham & Windham 1993). A duplicate specimen was verified by Dr. James Peck of the University of Arkansas at Little Rock. This plant was the only one observed at the site but had multiple stems so our collecting did not eradicate it. The plant is not known to be cultivated in the area so its mode of distribution to this site is unknown. No additional plants of this species were located in a check of the other pillars on this bridge and those of nearby bridges but additional populations of this fern might be found in similar habitats in the future in western Louisiana and eastern Texas.

Voucher specimen: **LOUISIANA. Beauregard Parish:** on pillar of bridge over Trout Creek off US 190 ca. 8 mi W of DeRidder, 28 Apr 2012, *McMillian 112* (BRIT, LSU).

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JOURNAL NOTICE

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NOTES ON THE IDENTIFICATION AND DISTRIBUTION OF THE SPECIES OF THE GENUS *GALIUM* (RUBIACEAE) IN LOUISIANA

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ABSTRACT

A key to and distribution of the species of the genus *Galium* in Louisiana are presented. Three species are reported new to the Louisiana flora: *Galium anglicum* Huds., *G. asprellum* Michx., and *G. divaricatum* Pourr. ex Lam while three other species (*G. obtusum* Bigelow, *G. trifidum* L., and *G. orizabense* Hemsl.) are excluded. The current number of species includes three introduced annuals, two native annuals, and seven native perennials.

RESUMEN

Se presenta una clave de las especies del género *Galium* y su distribución en Luisiana. Se citan tres especies nuevas para la flora de Luisiana: *Galium anglicum* Huds., *G. asprellum* Michx., y *G. divaricatum* Pourr. ex Lam mientras que se excluyen otras tres especies (*G. obtusum* Bigelow, *G. trifidum* L., y *G. orizabense* Hemsl.). El número actual de especies incluye tres anuales introducidas, dos anuales nativas, y siete perennes nativas.

Twelve species of the genus *Galium* (Rubiaceae) are listed for Louisiana in the Plants Database (USDA, NRCS 2012) and by MacRoberts (1984) while 11 species are listed by Thomas and Allen (1998). Specimens of *Galium* collected in Louisiana were examined and annotated from the following herbaria: Louisiana State University, Baton Rouge (LSU); Louisiana State University in Shreveport (LSUS); Louisiana Tech University, Ruston (LTU); University of Louisiana at Lafayette (LAF); and University of Louisiana at Monroe (NLU). The in-state distribution is based on these data as well as the work of Thomas and Allen (1998). The keys to species, descriptions, and habitat information are based on field observations, herbarium specimens, and published works including Correll and Johnston (1970), Diggs et al (1999) Lipscomb and Nesom (2007), Radford et al (1968), and Wunderlin (1998). The current list of *Galium* species in Louisiana numbers 12 and includes three introduced annuals, two native annuals, and seven native perennials.

The following *Galium* taxa are new to the Louisiana flora: *Galium anglicum* Huds., *G. asprellum* Michx., and *G. divaricatum* Pourr. ex Lam. The following *Galium* taxa are excluded from the Louisiana Flora: *G. obtusum* Bigelow, *G. trifidum* L., and *G. orizabense* Hemsl. *Galium obtusum* Bigelow was reported from a number of parishes by Thomas and Allen (1998) but all herbarium specimens examined were *G. tinctorium* with three petals only. No specimens with four petals were seen as reported for G. obtusum by Puff (1977). Thomas and Allen (1998) reported *Galium trifidum* L. from Orleans and West Feliciana parishes but these were miss-identified *G. triflorum* Michx. *Galium orizabense* Hemsl. is reported for Louisiana by USDA NRCS (2012) based on Thomas and Allen (1984), but this publication does not include the genus *Galium*. No herbarium specimens of *G. orizabense* from Louisiana were found.

KEY TO THE SPECIES OF *GALIUM* IN LOUISIANA

1. Fruit fleshy.
   2. Leaves elliptic, less than four times as long as wide ____ **6. G. hispidulum**
   2. Leaves linear, more than four times as long as wide ____ **11. G. uniflorum**
1. Fruit dry, not fleshy.
   3. Fruit distinctly bristly.
      4. Flowers and fruits short pedicelled.
         5. Plant perennial; blades ovate, three veined, longer than 10 mm ____ **.4. G. circaezans**
         5. Plant annual; blades oblong, one veined, shorter than 10 mm ____ **12. G. virgatum**
      4. Flowers and fruits long pedicelled.

6. Stems and leaves distinctly scabrous.
   7. Leaves in whorls of six; blades 1 cm or shorter, 1 mm or narrower ____ **7. G. parisiense**
   7. Leaves in whorls of eight or seven; blades longer than 1 cm, wider than 1 mm ____ **2. G. aparine**
6. Stems and leaves glabrous to pubescent but not distinctly scabrous.
   8. Leaves in whorls of six; blades glabrous or with scabrous margins, apex mucronate ____ **10. G. triflorum**
   8. Leaves in whorls of four; blades pubescent, apex not mucronate ____ **8. G. pilosum**

3. Fruit smooth.
   9. Plant perennial.
      10. Stems and leaves distinctly scabrous ____ **3. G. asprellum**
      10. Stems and leaves glabrous ____ **9. G. tinctorium**
   9. Plant annual.
      11. Inflorescence relatively diffuse, branches divaricate; ultimate fruits (2–)3–6(–7) nodes beyond primary stem axis (with largest leaves); first inflorescence internode (beyond primary stem axis) 15–50 mmlong; ____ **5. G. divaricatum**
      11. Inflorescence relatively strict, branches ascending; ultimate fruits 2–3(–4) nodes beyond primary stem axis (with largest leaves); first inflorescence internode (beyond primary stem axis) 3–12(–20) mm long ____ **1. G. anglicum**

1. Galium anglicum Huds. (*G. parisiense* L. var. *trichocarpum* Tausch) is an introduced annual. It is known from only one location in Louisiana. Bossier Parish: Median and roadbank of I-20 at U.80 over-pass just W of Rest Area, E of Filmore-Haughton Exit Sec. 10, T18N R11W, *Thomas 156334*, 11 May 1998 (NLU). This collection is the first for Louisiana. Lipscomb and Nesom (2007) report this species from AL, AR, GA, MO, NC, OK, SC, TN, TX, VA, and WV.

2. Galium aparine L. is a native annual that is common and widespread in the state in roadside ditches, lawns, vacant lots and other disturbed areas and is reported from all 64 parishes (Fig. 1). It is reported from all 48 conterminous states and AK in the US and most of Canada (USDA NRCS 2012).

3. Galium asprellum Michx. is a native (but perhaps introduced in Louisiana) perennial. The collection data for this species in Louisiana are: Caddo Parish: along railroad tracks near center of Kansas City Southern Railroad Yard W of La 173, E of Blanchard, sec 19 T18N R14W, *Thomas 65094*, 29 May 1979 (NLU). This is the first collection for Louisiana and possibly represents a one-time introduction that did not persist. This species is a northern species and is reported from MO, TN, NC, and all states to the north of these except for KY (USDA, NRCS 2012). It is also reported from New Brunswick, Newfoundland, Ontario, and Quebec in Canada.

4. Galium circaezens Michx. is a native perennial of well-drained forests mostly along streams in the pine regions of the state (Fig. 2). It is reported from all the eastern states in the US west to TX, OK, KS, and NE (absent from ND and SD). It is also reported from Ontario and Quebec in Canada (USDA, NRCS 2012)

5. Galium divaricatum Pourr. ex Lam. is an introduced annual. The collection data are Caddo Parish: along railroad tracks near North Lakeshore Drive west of La 173 SWEof Blanchard Sec. 19, T18N R14W, *Thomas 83085*, 17 Apr 1983 (NLU); and at the same location; *Thomas 99537*, 26 Apr 1987 (NLU) and *Thomas 88323*, 28 Apr 1984 (NLU). Along railroad tracks in Kansas City Southern Yard west of La 169, south of Blanchard at North Lakeshore Drive Sec. 19, T19N R14W, *Thomas 76697*, 21 May 1981 (NLU). These collections are the first for Louisiana. Lipscomb and Nesom (2007) report this species from AL, IN, KY, and TX. It is reported from AL, AR, CA, GA, IN, KY, LA, MO, MS, NC, OR, TN, VA, VT, and WV by USDA NRCS (2012).

6. Galium hispidulum Michx. is a native perennial of sandy, well-drained soils. It is reported from three parishes in SE and NW Louisiana (Fig. 3). It is an Atlantic and Gulf coastal plain species with reports also from AL, FL, GA, MD, MS, NC, NJ, SC, TX, and VA.

7. Galium parisiense L. is an introduced annual. It is recorded from roadsides and other disturbed areas mostly in western Louisiana (Fig. 4). Lipscomb and Nesom (2007) report this species from AL, IN, KY, MO, and TN. USDA NRCS (2012) reports it from CA, OR, and WA in the US and BC in Canada.

8. Galium pilosum Ait. is a native perennial that is widespread in Louisiana. Its habitats include pine forests, hardwood forests, prairies, and the northern portion of the coastal marsh but is absent from the large floodplain areas along the southern Mississippi River and lower coastal marsh (Fig. 5). It is also reported from AL,

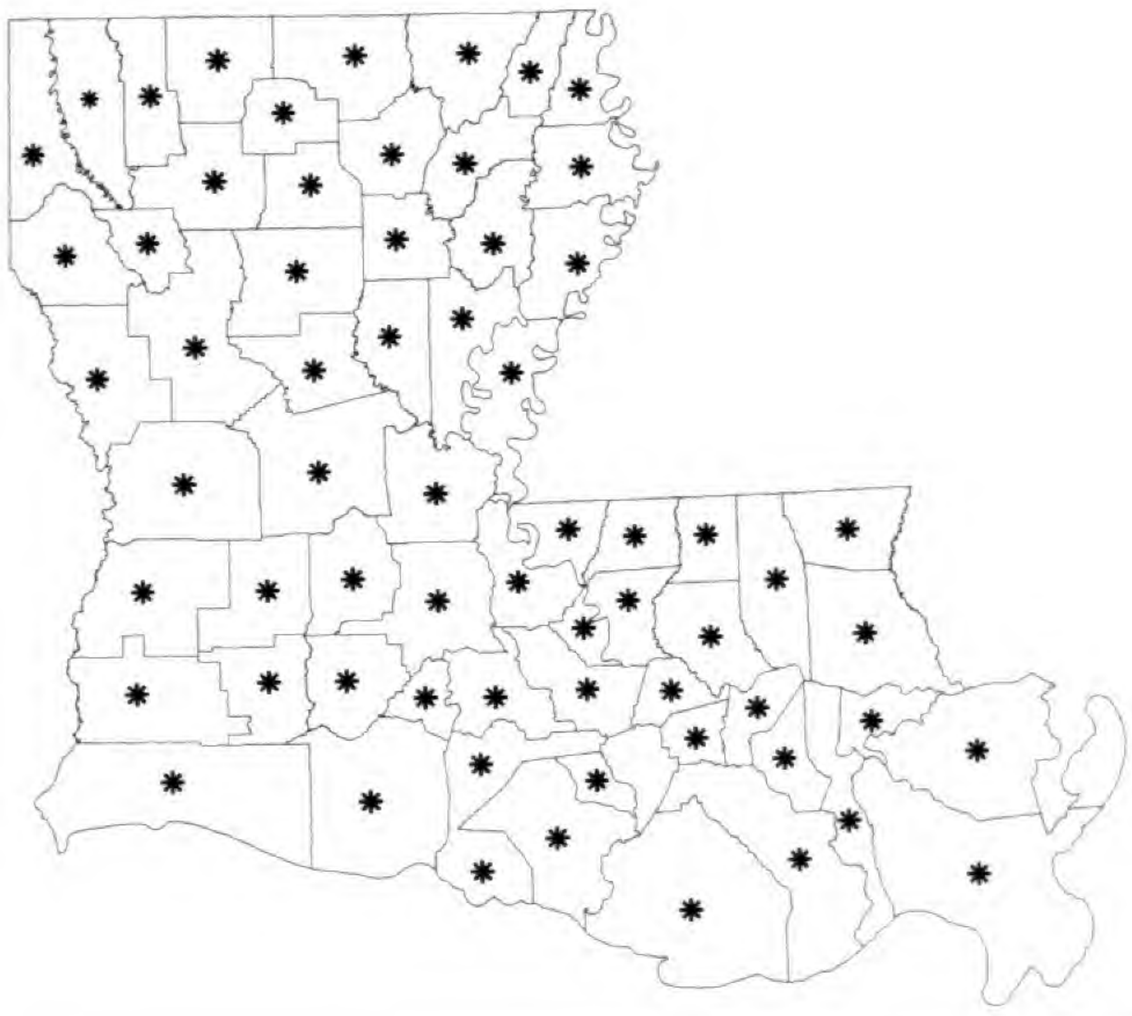


Fig. 1. Known distribution of *Galium aparine* in Louisiana.

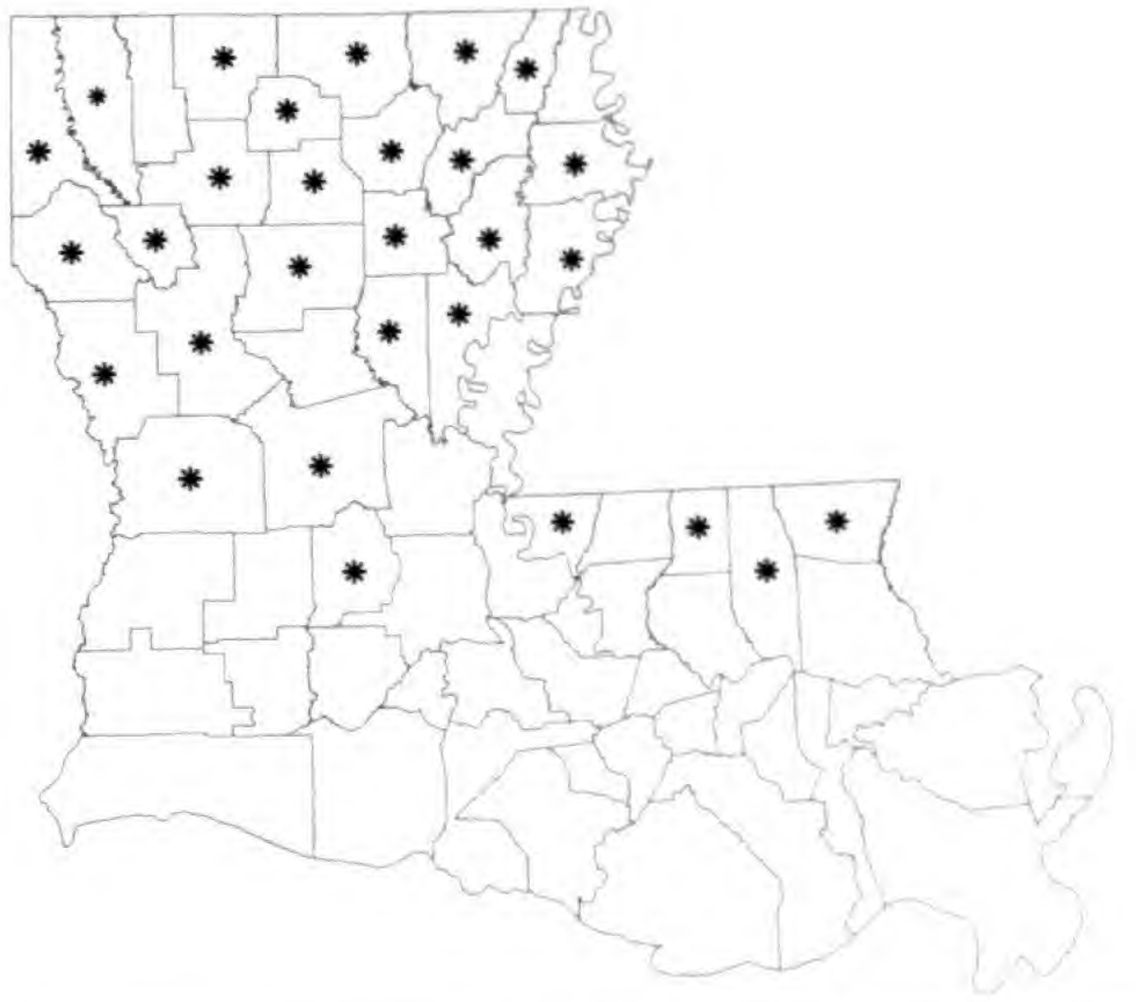


Fig. 2. Known distribution of *Galium circaezans* in Louisiana.

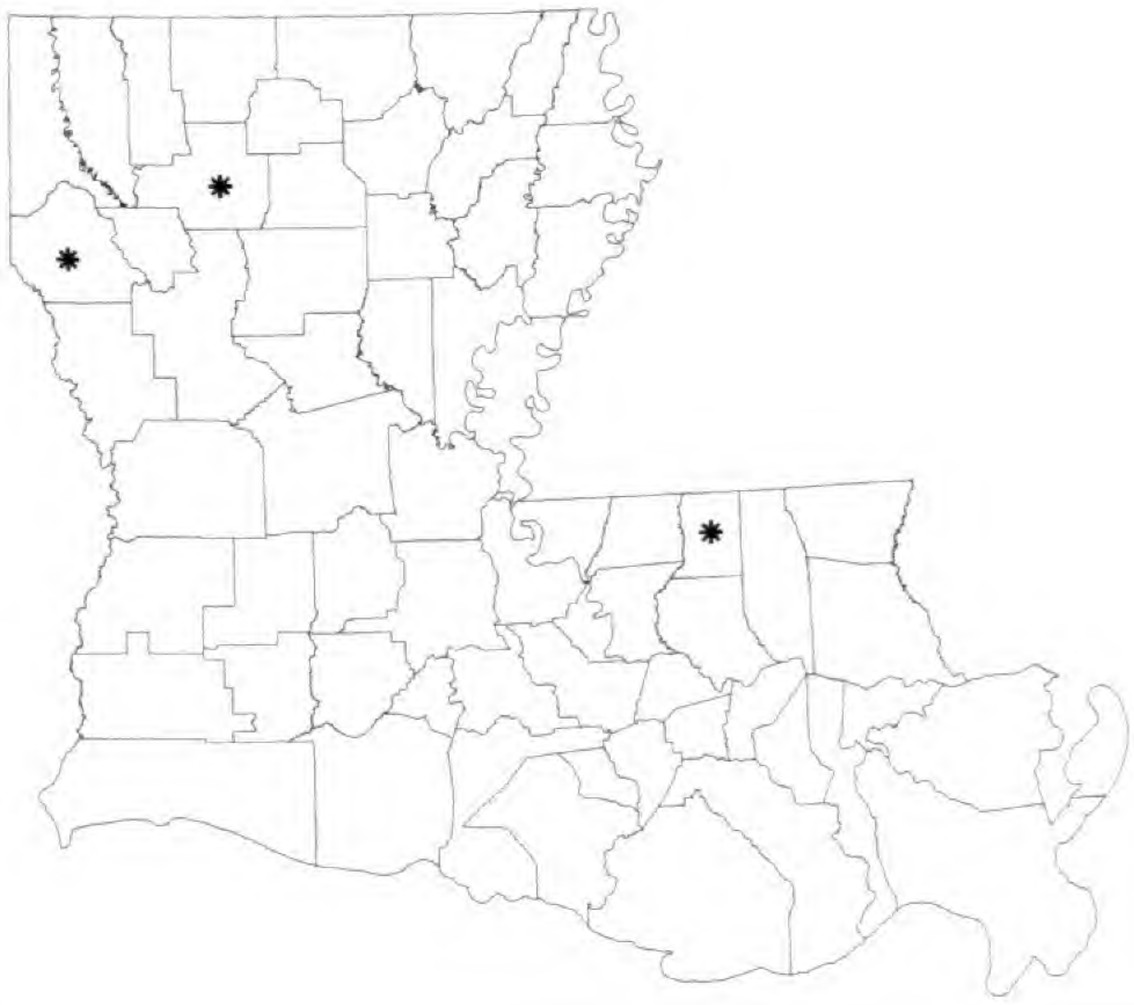


Fig. 3. Known distribution of *Galium hispidulum* in Louisiana.

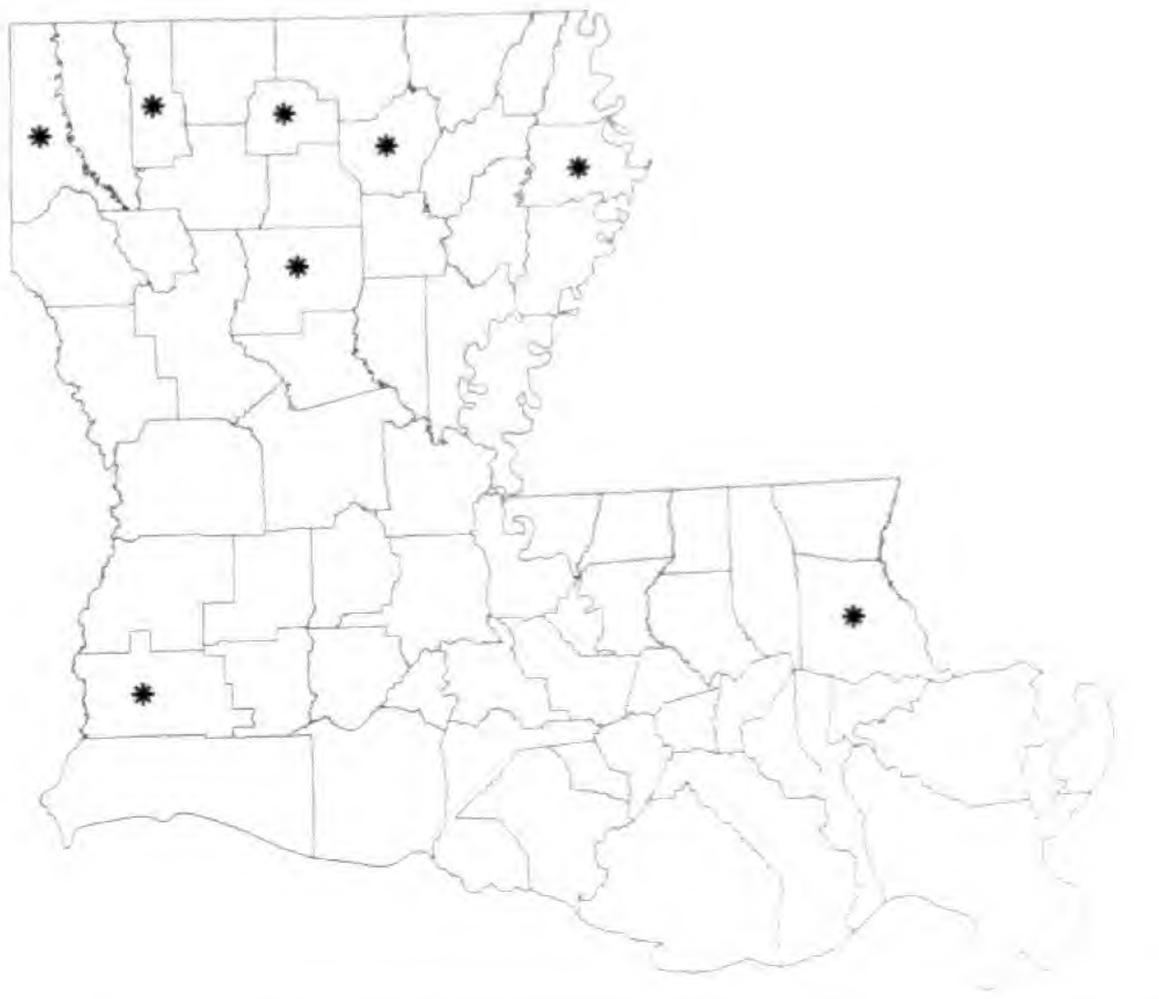


Fig. 4. Known distribution of *Galium parisiense* in Louisiana.

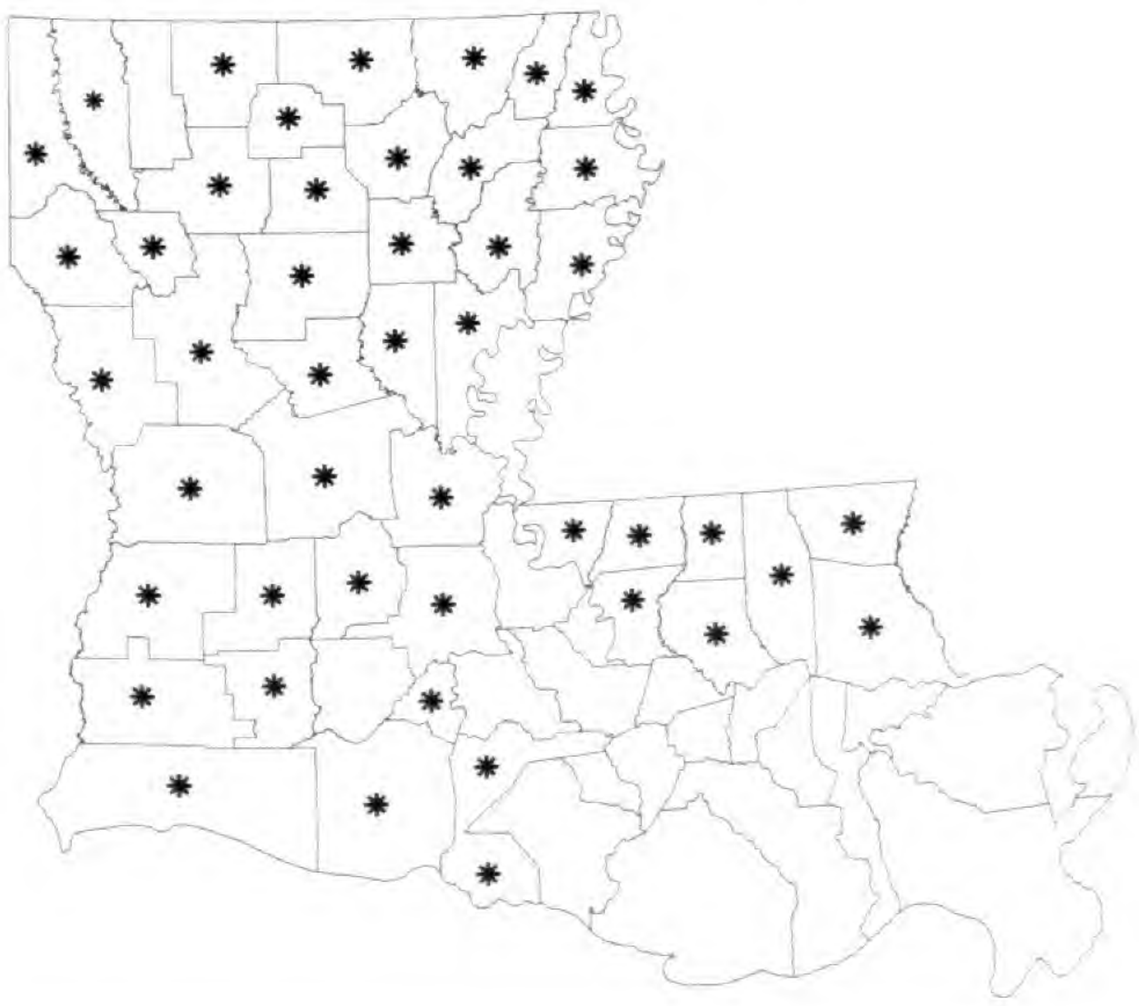


Fig. 5. Known distribution of *Galium pilosum* in Louisiana.

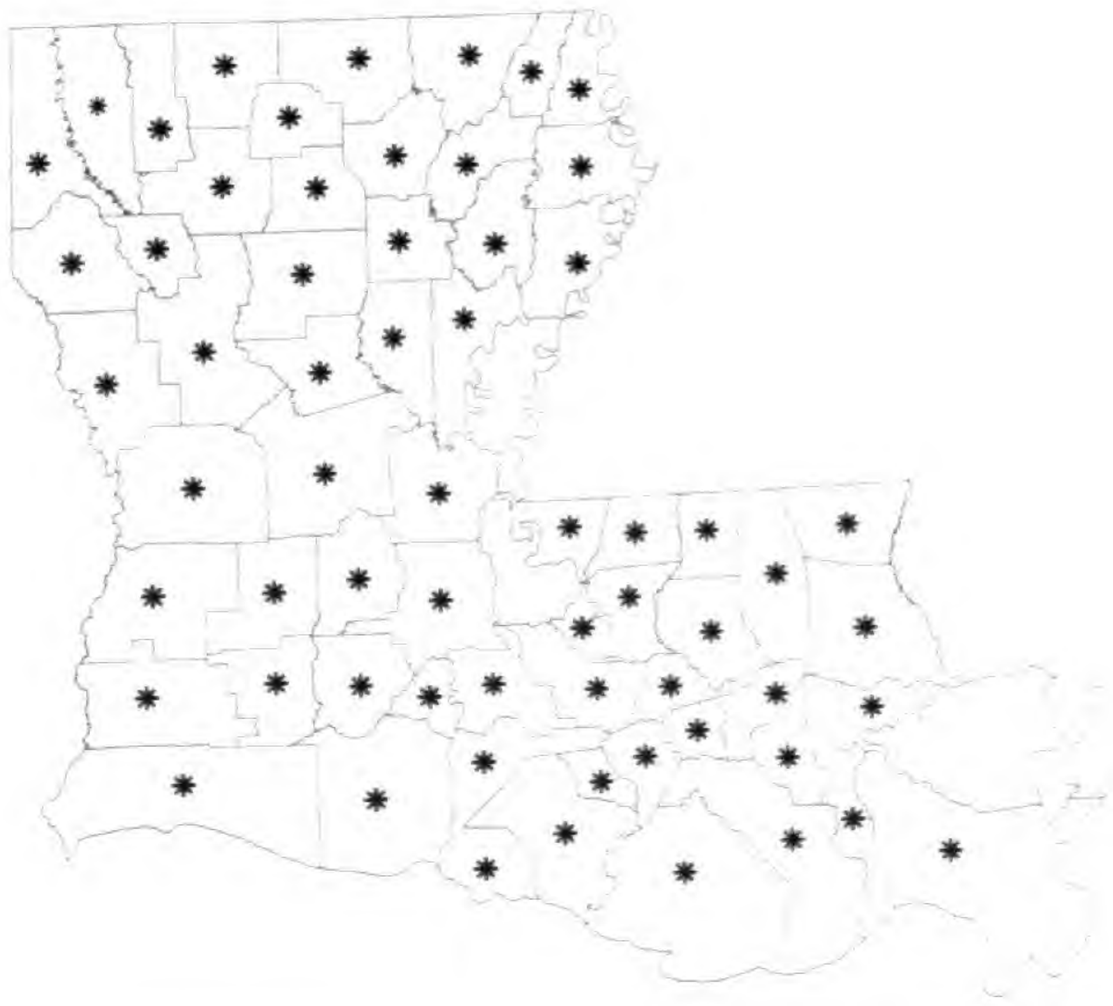


Fig. 6. Known distribution of *Galium tinctorium* in Louisiana.

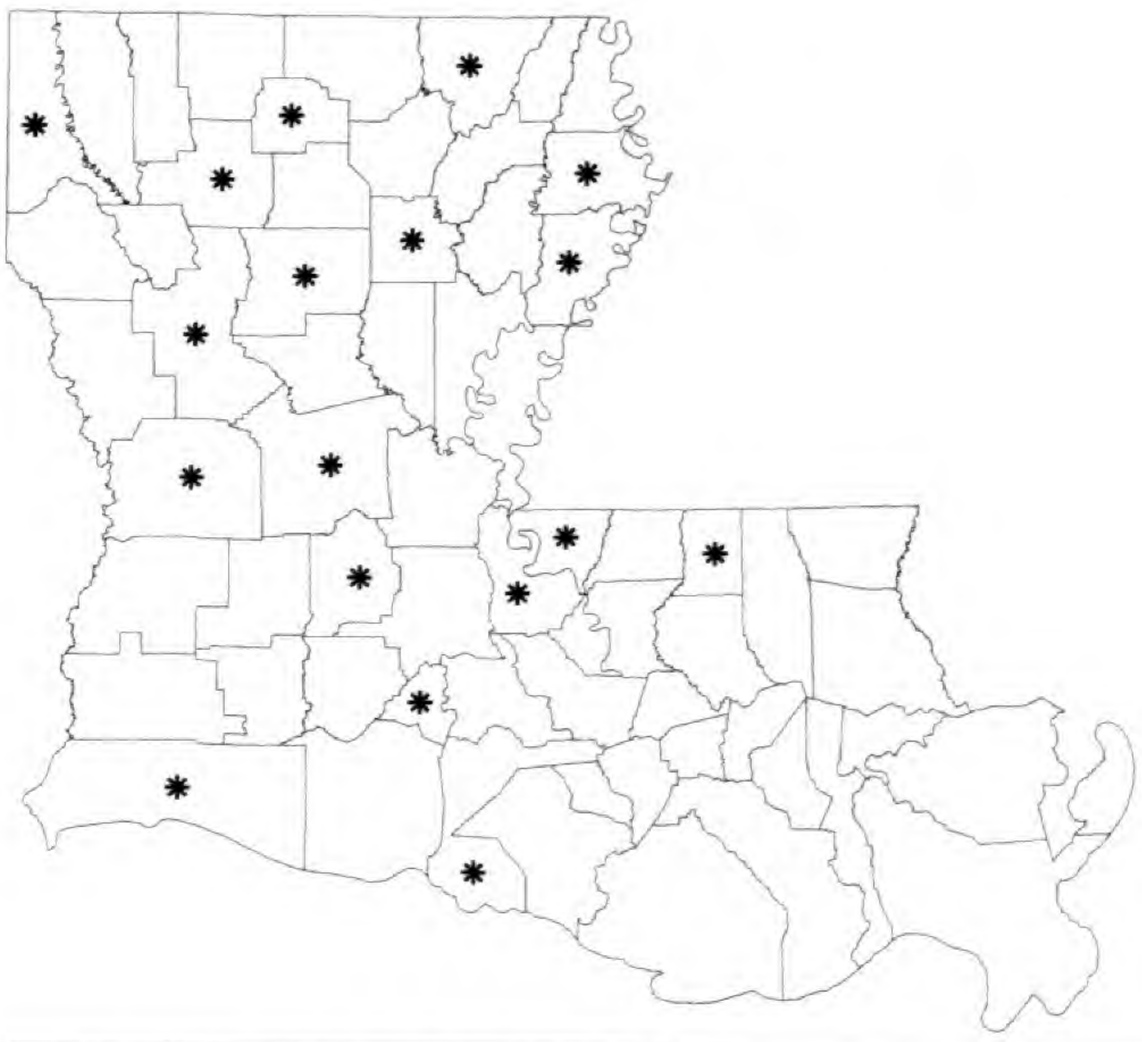


Fig. 7. Known distribution of *Galium triflorum* in Louisiana.

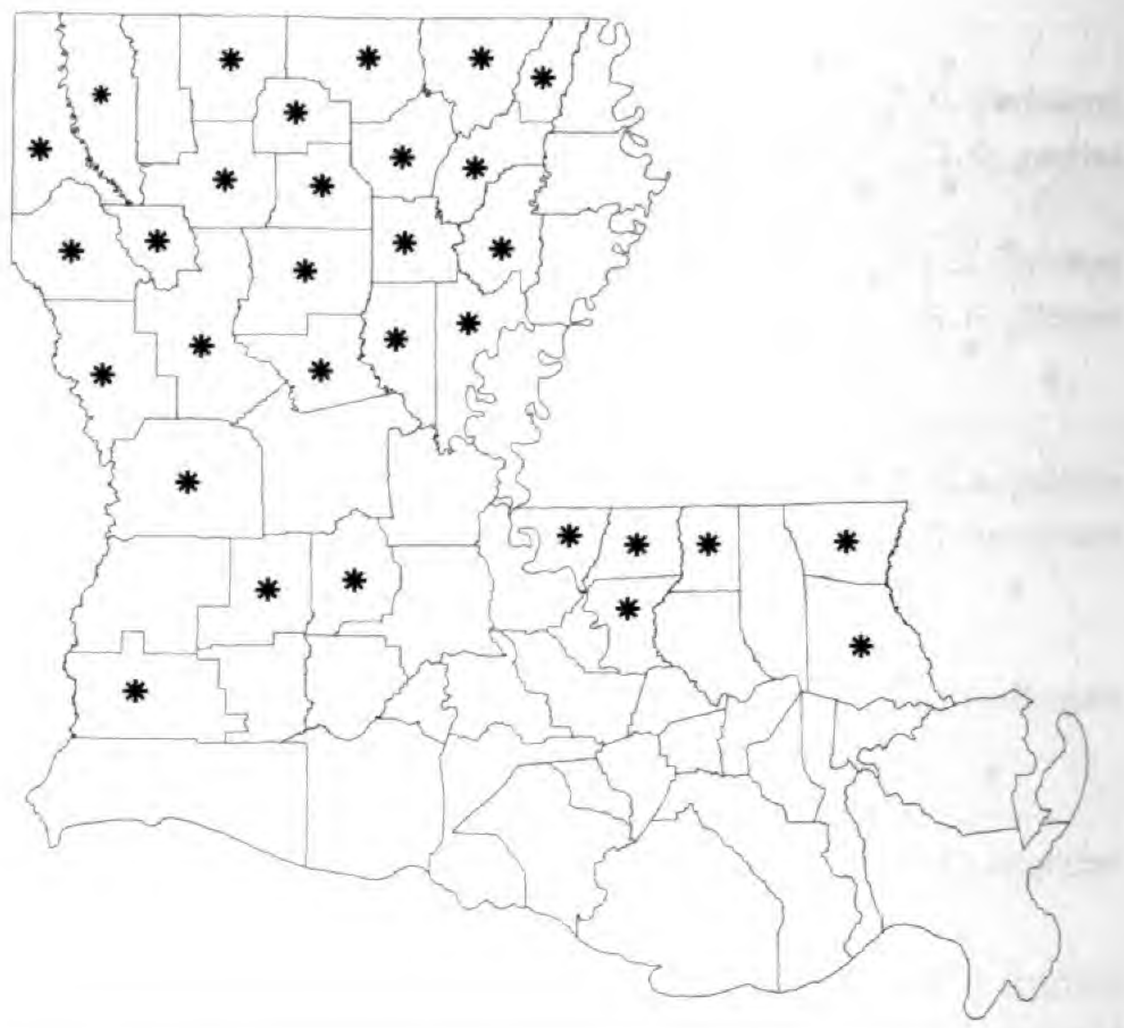


Fig. 8. Known distribution of *Galium uniflorum* in Louisiana.

AR, CO, DC, DE, FL, GA, IL, IN, KS, KY, LA, MA, MD, MI, MO, MS, NC, NH, NJ, NM, NY, OH, OK, PA, RI, SC, TN, TX, VA, VT, and WV by USDA NRCS (2012).

9. Galium tinctorium L. is a native perennial. It is widespread across the state and probably occurs in all 64 parishes with reports from 62 (Fig. 6). It is usually found in roadside ditches, edges of forests, and along streams. It is reported from all the eastern states in the US west to TX, OK, KS, and NE (absent from ND and SD) (USDA, NRCS 2012). It is also reported from Labrador, New Brunswick, Newfoundland, Ontario, and Quebec in Canada.

10. Galium triflorum Michx. is a native perennial that is widely distributed across the state mostly in hardwood forests along streams (Fig. 7). It is reported from all 48 conterminous states in the US, AK, and all provinces in Canada (USDA NRCS 2012).

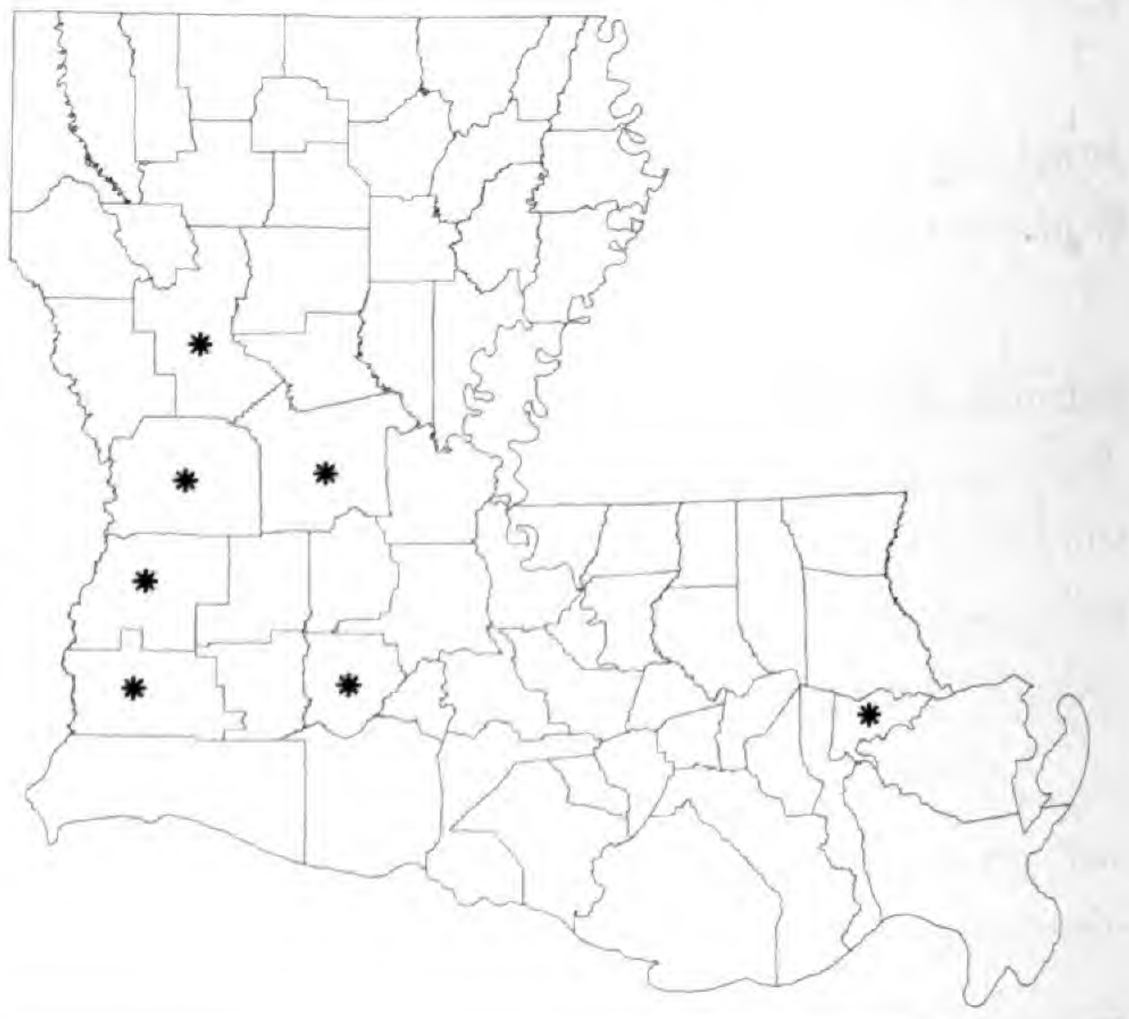


Fig. 9. Known distribution of *Galium virgatum* in Louisiana.

11. Galium uniflorum Michx. is a native perennial. It is a plant of hardwood forests along streams in fairly well drained areas within the pine regions of the state (Fig. 8). In the US, it is restricted to the coastal plain area with reports from AL, AR, FL, GA, LA, MS, NC, SC, TX, and VA (USDA NRCS 2012)

12. Galium virgatum Nutt. is a native annual. It is reported mostly from prairie areas in west central Louisiana (Fig. 9). This species is considered to be rare in Louisiana (S2) (Louisiana Natural Heritage Program 2012). In the United States, it is also reported from AL, AR, IL, KS, MO, MS, OK, SC, TN, and TX (USDA NRCS 2012).

ACKNOWLEDGMENTS

I greatly appreciate the detailed reviews by Michael MacRoberts and an anonymous reviewer.

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NEW BOOK ANNOUNCEMENT

Helen Hamilton and Gustavus Hall. 2013. **Wildflowers & Grasses of Virginia's Coastal Plain.** (ISBN: 978-1-889878-41-6, flexbound). Sida, Botanical Miscellany 40. Botanical Research Institute of Texas Press, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A. (**Orders:** www.britpress.org, 1-817-332-4441). $24.95, 288 pp., 6" × 9".

From articles written and published by the first author in newspapers over the past 7 years, a book has been created about Virginia's Coastal Plain wildflowers and grasses. The second author Dr. Gustavus Hall, Professor Emeritus, College of William and Mary, rewrote portions of the text to ensure botanical accuracy. Louise Menges, Editor, maintained the photo inventory, selected appropriate images for each page, and designed the layout of each page.

Sponsored by the John Clayton Chapter of the Virginia Native Plant Society, many plants included are native to the Coastal Plain of Virginia; some are introduced from other areas in the U.S. and from other countries. Included are non-woody plants often seen along roadsides, in meadows, gardens, and lawns. Many are weedy, with small flowers, not usually seen in field guides. Also included are grasses commonly seen in Virginia's Coastal Plain.

The plants included here occur in most counties of the Coastal Plain of Virginia, and some may be found throughout the Atlantic and Gulf coastal plains from Cape Cod to Mexico. Originally, the book was conceived to include only plants native to the Coastal Plain. In decades of field work, the authors have observed very conspicuous non-native (introduced) plants displacing natives in many locations. These familiar, introduced plants are in the book, to help users distinguish desirable native plants from unwanted species.

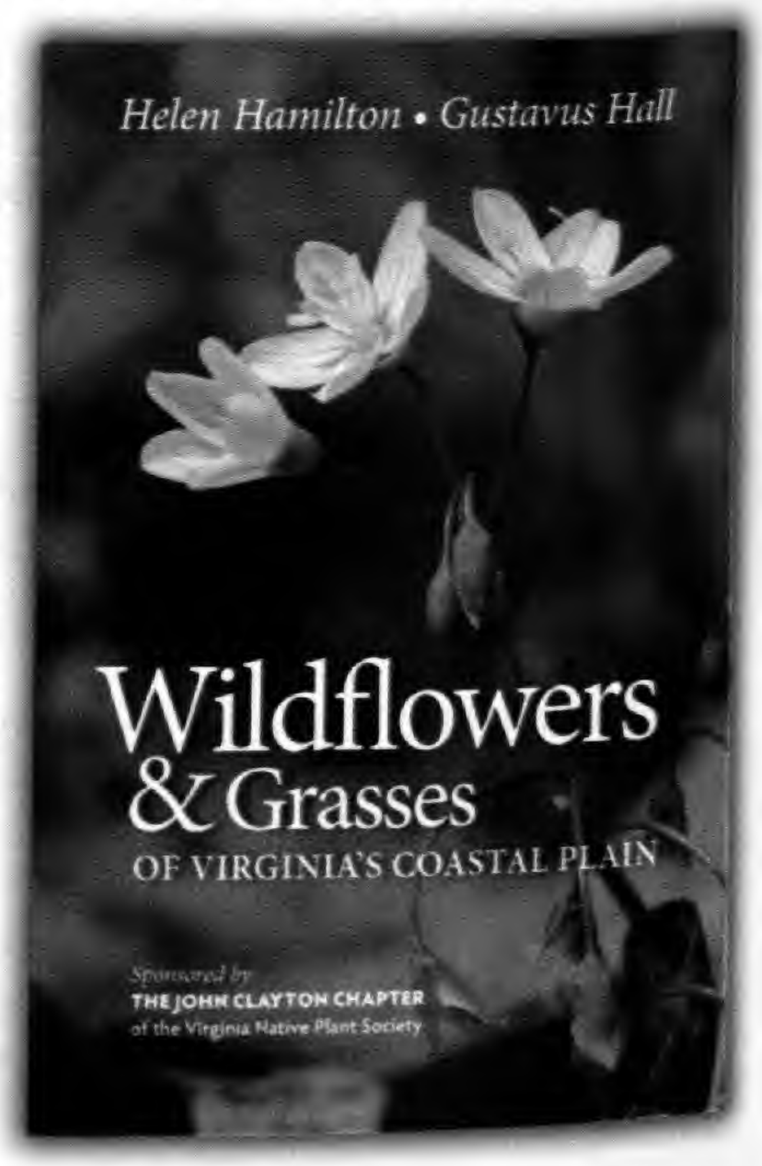
The plants are arranged in the book by flower color (white, yellow, orange, red, pink, blue, violet, green, brown), indicated by a colored rectangle on the upper edge of the page. The grasses and grass-like plants (tan rectangle) are in the last section of the book. Within each color group the plants are arranged alphabetically by families. Photographs on each page show the most prominent feature of each plant, usually the flower.

Text follows the photographs with user-friendly descriptions of the plant's characteristics, habitat, range and growing conditions, and interesting facts about uses in folk medicine, by the Native Americans, and origins of the plant's names.

All photographs were contributed by members of local chapters of the Virginia Native Plant Society: Ellis Squires from the Northern Neck Chapter; and from the local John Clayton Chapter, Teta Kain, Seig Kopinitz, Louise Menges, Kathi Mestayer, Phillip Merritt, and Jan Newton; and Felice Bond from the Historic Rivers Chapter of the Virginia Master Naturalists.

Dr. Donna Ware, retired Herbarium Curator, College of William and Mary, has written the Preface; the book was peer-reviewed by Dr. John Hayden, Botanist, University of Richmond; and Bland Crowder, Editor of the *Flora of Virginia*, has done the copy editing.

Additional information about the plants can be found in the "Further Reading" section of the book which follows the list of references the authors have used throughout. For readers wishing more information about each plant featured within, *Flora of Virginia* (2012) is the definitive resource for technical botanical information.



"*Wildflowers and Grasses of Virginia's Coastal Plain* is much more than a field guide to the region. The scientific accuracy of the volume is augmented by the useful and idiosyncratic text which is woven throughout. This style of writing allows the reader to painlessly obtain a well-rounded education in taxonomy and species relationships, the derivation of scientific names, uses of plants by humans, quirks of plant habitats and distributions, and innumerable fascinating and useful facts that seldom appear in any plant guide. With the inclusion of grass-like species, the book also ventures into territory often neglected by popular botanical texts. In short, the reader will become well-informed and enjoy the process!"—*Johnny Townsend, co-author of* ***Flora of Virginia*** *and Botanist, Virginia Natural Heritage Program, Department of Conservation and Recreation, Richmond, Virginia.*

SYNOPSIS OF THE GENUS *STYLISMA* (CONVOLVULACEAE) IN LOUISIANA

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ABSTRACT

The distribution, description, and a key to the species of the genus *Stylisma* (Convolvulaceae) in Louisiana are presented. The current number of species includes three native perennial vines: *S. aquatica* (Walt.) Raf., *S. humistrata* (Walt.) Chapm., and *S. pickeringii* (Torr. ex M.A. Curtis) A. Gray. Two species, *Stylisma patens* (Desr.) Myint and *S. villosa* (Nash) House, are excluded from the Louisiana flora.

RESUMEN

Se presentan la distribución, descripción, y una clave de las especies del género *Stylisma* (Convolvulaceae) en Luisiana. El número actual de especies incluye tres trepadoras perennes: *S. aquatica* (Walt.) Raf., *S. humistrata* (Walt.) Chapm., y *S. pickeringii* (Torr. ex M.A. Curtis) A. Gray. Dos especies, *Stylisma patens* (Desr.) Myint y *S. villosa* (Nash) House, se excluyen de la flora de Luisiana.

The genus *Stylisma* (Convolvulaceae) in Louisiana includes native perennial vine species with five reported by the USDA, NRCS (2012), MacRoberts (1984) and Thomas and Allen (1998). The specimens of *Stylisma* from Louisiana were examined and annotated from the following herbaria: Louisiana State University, Baton Rouge (LSU), Louisiana State University in Shreveport (LSUS), Louisiana Tech University, Ruston (LTU), University of Louisiana at Lafayette (LAF), and University of Louisiana at Monroe (NLU). The in-state distribution is based on these data and the work of Thomas and Allen (1998). The report for *S. patens* was based on a misidentified specimen of *S. humistrata* and the two reports of *S. villosa* were based on misidentified specimens of *S. aquatica*. Consequently, these two species should be excluded from the Louisiana flora. *Stylisma villosa* has a white corolla and villous filaments while *S. aquatica* exhibits a lavender, pink or purplish red corolla and glabrous filaments (Myint 1966). The range of *S. villosa* includes FL, GA, MS and TX with *S. aquatica* reported from AL, AR, FL, GA, LA, MS, NC, SC, and TX (Myint 1966; USDA NRCS 2012). *Stylisma patens* has narrower leaves (less than 1.2 cm wide) and mostly solitary flowers compared to the wider leaves (greater than 1.2 cm) and flowers, mostly in cymes of three, of *S. humistrata* (Myint 1966). The range of *S. patens* includes Al, FL, GA, MS, NC, and SC while *S. humistrata* is reported from AL, AR, FL, GA, LA, MS, NC, SC, TN, TX, and VA (Myint 1966; USDA NRCS 2012). The leaves of plants within the genus *Stylisma* are alternate, simple, entire, and with pinnate major veins. The inflorescence is an axillary corymb. The perfect regular flowers have five imbricate sepals, five fused petals with the corolla campanulate to funnelform, and five epipetalous stamens. The ovary is superior and the fruit is a capsule with four seeds.

KEY TO THE SPECIES OF *STYLISMA* IN LOUISIANA

1. Leaf blades linear; bracteoles of flowers longer than 1 cm; styles fused nearly to base of stigmas; stylar branches shorter than 5 mm _____ **3. S. pickeringii**
1. Leaf blades oblong to oblong-elliptic; bracteoles of flowers shorter than 1 cm; styles free or fused only in lower portion; stylar branches longer than 5 mm.
   2. Corolla lavender to red; calyx pubescent; filaments mostly glabrous _____ **1. S. aquatica**
   2. Corolla white; calyx glabrous; filaments pubescent _____ **2. S. humistrata**

1. Stylisma aquatica (Walt.) Raf. Leaf blades oblong to elliptic, short densely pubescent, sepals pubescent, corolla lavender, style deeply lobed to ½ or more of length, filaments glabrous. An infrequent plant of pine flatwoods and savannahs in the southwest and southeast part of the state (Fig. 1). May–July (*Bonamia aquatica* (Walt.) A. Gray, *Bonamia michauxii* (Fern. & Schub.) K.A. Wilson, *Breweria aquatica* (Walt.) A. Gray, *Breweria michauxii* Fern. & Schub.).

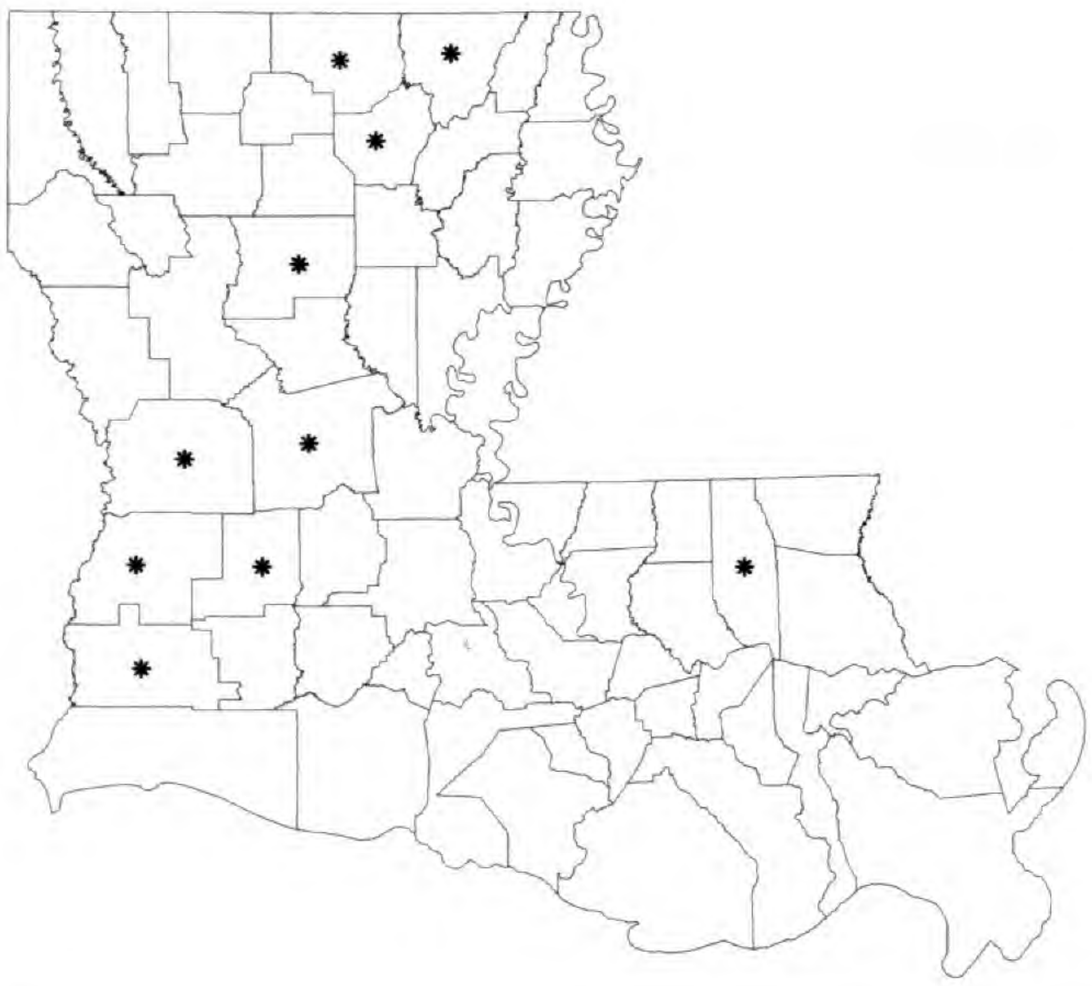


Fig. 1. Known distribution of *Stylisma aquatica* in Louisiana.

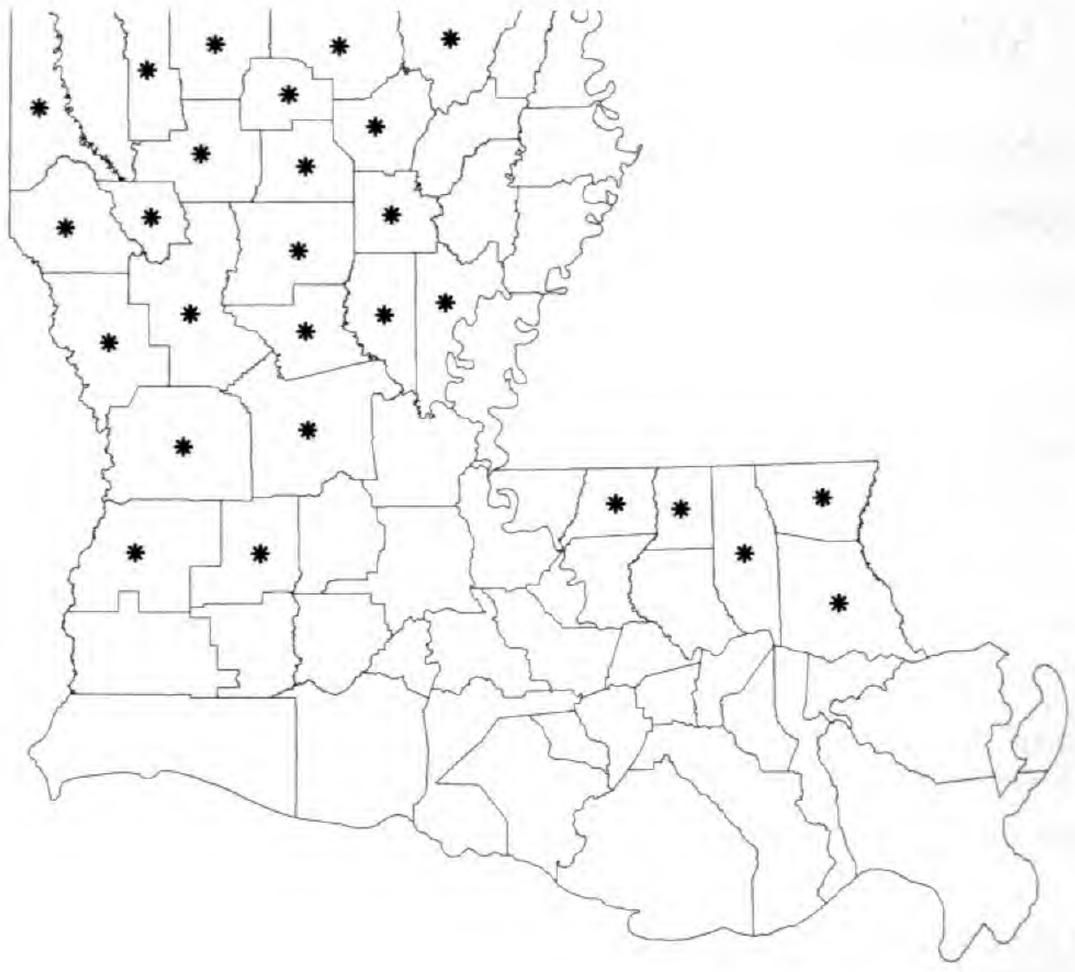


Fig. 2. Known distribution of *Stylisma humistrata* in Louisiana.

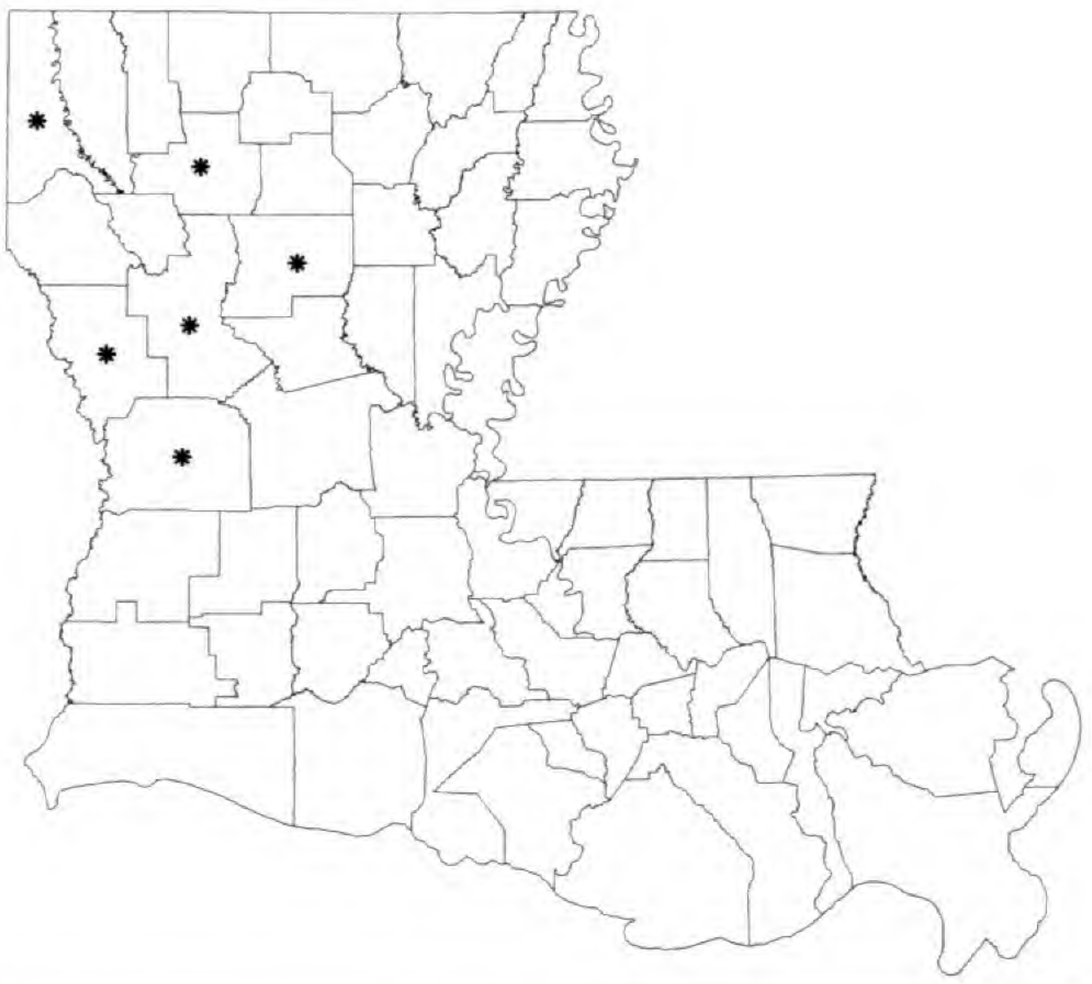


Fig. 3. Known distribution of *Stylisma pickeringii* var. *pattersonii* in Louisiana.

2. Stylisma humistrata (Walt.) Chapm. Leaf blades oblong to elliptic, sparsely pubescent, sepals glabrous, corolla white, style not lobed, filaments pubescent. The most common and widespread of the Louisiana species of this genus in sandy pine forests in the pine regions of the state (Fig. 2). May to October (*Bonamia humistrata* (Walt.) A. Gray, *Breweria humistrata* (Walt.) A. Gray.

3. Stylisma pickeringii (Torr. ex M.A. Curtis) A. Gray var. **pattersonii** (Fern. & Schub.) Myint. Leaf blades linear, sparsely pubescent, sepals pubescent, corolla white, style not lobed, filaments glabrous. An infrequent species of very sandy areas in western and northwestern Louisiana (Fig. 3). May–August (*Breweria pickeringii* (Torr. ex M.A. Curtis) A. Gray var. *pattersonii* Fern. & Schub., *S. pattersonii* (Fern. & Schub.) G.N. Jones).

ACKNOWLEDGMENTS

Michael MacRoberts and Andrew McDonald provided helpful comments.

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CONFIRMATION OF KARIBA-WEED, *SALVINIA MOLESTA* (SALVINIACEAE) IN THE CALCASIEU RIVER BASIN, LOUISIANA

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ABSTRACT

Heavy rains in southwestern Louisiana during July 2012 flushed an immense amount of *Salvinia molesta* into the Calcasieu River near Lake Charles, Louisiana. This is the first confirmed sighting of *S. molesta* in Calcasieu Parish, Louisiana. The source for this infestation is unknown but is likely from a population or populations somewhere in the Calcasieu River basin upriver from the saltwater barrier dam located just north of Lake Charles. Because of the negative ecological and economic impacts that can accrue from this noxious species, the monitoring of this situation will be ongoing.

RESUMEN

Las lluvias torrenciales en el suroeste de Luisiana durante julio de 2012 han sacado una cantidad inmensa de *Salvinia* del Río Calcasieu cerca de Lake Charles, Luisiana. Este es el primer avistamiento confirmado de *Salvinia molesta* en Calcasieu Parish, Luisiana. La fuente de esta infestación es desconocida, pero es probable la procedencia de una o varias poblaciones en algún lugar de la cuenca del río Calcasieu por encima de la barrera de agua salada, ubicada justo al norte de Lake Charles.

As described by Neyland (2011), *Salvinia molesta* Mitchell, kariba-weed, is an introduced aquatic fern with horizontal rhizomes. Fronds are ovate, aquatic, and up to 4 cm long with rows of stiff hairs. Each hair has the appearance of an eggbeater. The submerged leaves are dark brown with root-like fibers. Sporocarps are formed in chains but rarely produce fertile spores. The species inhabits lakes, ponds, marshes, sluggish rivers and streams along the southern tier of states from CA to NC. Plants are sensitive to freezing temperature and elevated salinity.

Native to southeastern Brazil, *Salvinia molesta* has become a serious threat to aquatic systems in the warm-temperate regions of the United States (Jacono et al. 2001). Exponential vegetative growth potential (Mitchell & Tur 1975) and tolerance to environmental stress (Whitman and Room 1991) allows this species to become a noxious weed in much of its range. On July 15, 2012, large numbers of individuals of *Salvinia molesta* were observed floating down the Calcasieu River adjacent to Shell Beach Road along the southern shore of Lake Charles in Calcasieu Parish, LA. This is the first recorded sighting of this species in the Parish.

On July 16, 2012, large numbers of *S. molesta* were observed on the western side of the Calcasieu River along River Road in northern Lake Charles just south of the saltwater barrier dam. Plants were observed in great abundance along the northern shore of Lake Charles on July 17, 2012. Specimens from each of the three locations, including GPS coordinates, were collected and are housed in the McNeese State University Herbarium (MCN).

Because this is the first recorded sighting of *Salvinia molesta* in Calcasieu Parish, the authors were surprised at its great abundance. The stretch of the Calcasieu River where the plants were observed is variably brackish. Sensitive to salinity and flowing water, the plants were not resident along this stretch of the river but were being flushed from a location or locations upriver of Lake Charles. Unusually heavy rainfall in western Louisiana during the first two weeks of July is the probable cause for this flushing. For example, rainfall recorded at Lake Charles from July 1–15 was 33.86 cm (13.33") (National Weather Service Website 2012).

This event generates an important question: where is the source population or populations of *Salvinia molesta*? The Calcasieu River originates in Vernon Parish and meanders generally southward for over 320 km

through Rapides, Allen, Jefferson Davis and Calcasieu parishes until it empties into the Gulf of Mexico in Cameron Parish. Of those north of Calcasieu Parish, only in Jefferson Davis Parish, adjacent to Calcasieu Parish, has *S. molesta* been documented (USDA, NRCS Website 2012). From information supplied by Mark Garland, from USDA, NRCS, a population of *S. molesta* was observed by Vanessa Morgan, research assistant at Portland State University, in *farm ponds* near the vicinity of Fenton, Louisiana, on November 6, 2004. This was confirmed by Scott Schales, biologist at the Louisiana Wildlife and Fisheries Department. However, because no specimen from this observation was collected, the exact location of the reported farm ponds is unknown. Unless these farm ponds drain into the Calcasieu River, either by Bayou Serpent or Little Bayou, these populations are not the specific source of the recent occurrence in Calcasieu River.

Charles Allen, owner of Allen Native Ventures, (pers. comm. 2012) reported that he has observed *Salvinia molesta* in Fullerton Lake, north of Pitkin in Vernon Parish. Fullerton Lake drains into Sixmile Creek which merges with the Whiskey Chitto, a tributary of the Calcasieu River. No specimen and, therefore, no specific collection information exists for this sighting. Additionally, no specimens or records of *S. molesta* from Vernon, Rapides, Allen, Jefferson Davis or Calcasieu parishes were found in a herbarium search from Louisiana State University (LSU), University of Louisiana at Monroe (NLU), University of Louisiana Lafayette (LAF) or McNeese State University.

With the return of drier weather, observations on July 19, 2012 from the original collection sites revealed that individuals of *Salvinia molesta* were no longer floating down the river and many individuals had died after being washed up along the banks. However with the return of heavy rainfall from July 20–22, a new flush of *S. molesta* occurred on the Calcasieu River. Additional specimens from this second flush were collected just upriver from the saltwater barrier dam north of Lake Charles and under the I-10 Bridge near Westlake, LA.

The origin of the *S. molesta* observed in the Calcasieu River remains unclear. Numerous habitats upriver from the saltwater barrier dam in Lake Charles could support populations of *S. molesta*. However, it is clear that *S. molesta* is firmly established at some location or locations in the Calcasieu River basin. Because of the negative ecological and economic impacts that can accrue from this noxious species, we intend to closely monitor the situation and will attempt to locate the original source of infestation.

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A QUANTITATIVE STUDY OF THE VEGETATION SURROUNDING A *XANTHORHIZA SIMPLICISSIMA* (RANUNCULACEAE) POPULATION AT FORT POLK IN WEST CENTRAL LOUISIANA

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ABSTRACT

Yellow root (*Xanthorhiza simplicissima* Marsh.) is a rare species (S1) in Louisiana known only from Vernon Parish. Quantitative data from 60 belt transects are reported and the plant community associated with yellow root is described. Yellow root in Louisiana is found along the edge of a baygall stream and is associated with the tree species *Magnolia virginiana*, *Nyssa biflora*, and *Liquidambar styraciflua*; the shrub species *Lyonia lucida*, *Ilex coriacea*, and *Vaccinium elliottii*; and the herbaceous species *Chasmanthium laxum*, *Mitchella repens*, and *Dichanthelium commutatum*. Yellow root is absent downstream in a more mesic area created by a larger natural levee associated with a larger stream.

RESUMEN

Xanthorhiza simplicissima Marsh. es una especie rara (S1) en Luisiana conocida solo de de Vernon Parish. Se aportan los datos cuantitativos de 60 transectos y se describe la comunidad de plantas asociadas con ella. *X. simplicissima* se encuentra en Luisiana a lo largo del borde de un torrente pantanoso y está asociada con tres especies arbóreas *Magnolia virginiana*, *Nyssa biflora*, y *Liquidambar styraciflua*; las especies arbustivas *Lyonia lucida*, *Ilex coriacea*, y *Vaccinium elliottii*; y las especies herbáceas *Chasmanthium laxum*, *Mitchella repens*, y *Dichanthelium commutatum*. *X. simplicissima* está ausente aguas abajo en un área más mésica creada por un dique natural asociado a un cauce más grande.

INTRODUCTION

Yellow root (*Xanthorhiza simplicissima* Marsh.) is a small deciduous shrub in the Ranunculaceae family. It is found throughout the eastern portion of the United States, ranging from Texas to Maine, with the exception of Vermont and New Hampshire (USDA NRCS 2012). Yellow root has been found in two of the three states that border Louisiana: Texas and Mississippi. The current county records for yellow root in East Texas include San Jacinto, Newton, and Jasper. In Mississippi, yellow root is widely distributed and has been found in Tishomingo and Itawamba counties in the northeast, Lafayette County in the north central, and Lauderdale, Jones, and Forrest counties in the southeast (USDA NRCS 2012). This species is demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery, and has a global ranking of 5 (NatureServe 2012). It is considered imperiled in Texas (S2) and critically imperiled in Florida and Louisiana (S1).

Yellow root was first reported in Louisiana in 1987 (Allen et al. 1987) from Vernon Parish, the only location in the state. In Vernon Parish, yellow root is located on US Forest Service/Fort Polk land in two locations that are ca 6000m apart. The larger population is found on an unnamed creek that drains generally from east to west and empties into the Ouiska Chitto Creek, just north of Lookout Road. At this location, the downstream distribution of yellow root apparently ends about 100m from where the tributary empties into the larger Ouiska Chitto Creek. With the flooding that can occur along this small stream, yellow root is probably distributed downstream very readily. In theory, it should be found farther downstream and even along the banks of the Ouiska Chitto Creek. Several searches downstream from this population on the banks of the tributary and continuing along the Ouiska Chitto Creek have not yielded any populations of yellow root. The second and much smaller population is south of Lookout Road on an unnamed creek that drains from east to west and empties into Drake's Creek.

The habitat reports for this species include shaded stream banks, moist woods, thickets, and rocky ledges (Parfitt 1997). The Louisiana Natural Heritage Program reports that small stream forests are the preferred

habitat for this species (Louisiana Natural Heritage Program 2011). In the Carolinas, the plant has been reported on shaded stream banks (Radford et al. 1968). Godfrey and Wooten (1981) described its habitat as river and stream banks, moist thickets, and springy places, usually shaded. The objectives of this study were to document the species that are associated with yellow root, describe the plant community where yellow root grows, and compare and contrast the plant community and species association downstream in habitats where yellow root has not been found.

Each Louisiana population is located in a baygall; the larger population within one of the baygalls studied by Allen et al. (2004). The soil along the stream bank where yellow root grows is mainly the Guyton-Iuka complex, frequently flooded (Soil Survey Division 2003).

METHODS

The larger population of yellow root was used for sampling. The distance (482 meters) along the creek from the farthest upstream to the farthest downstream location was measured and recorded. A 482 meter long macroplot was created to include the known range of yellow root along the tributary. Using a random number generator, fifty plot centers out of the 482 points were selected for sampling. Beginning from the last downstream yellow root location, a fifty meter macroplot was created downstream from that point and ten sampling locations were randomly selected out of the fifty potential points. All sixty (50 upstream and 10 downstream) sampling points were sampled using a 20 m x 1m belt transect. Each transect was centered over the stream and oriented perpendicular to the stream. The plant categories sampled included herbaceous plants, woody vines, shrubs and saplings (woody non-vine species shorter than 6 ft = 1.83 m), and trees and shrubs (woody non-vine species taller than 6 ft = 1.83m). During the sampling period, the number of stems in a sample for each species were counted and recorded. For herbaceous plants, woody vines, and shrubs and saplings, cover was determined by measuring the area occupied by the plant(s). The cover percent was calculated by multiplying the area times the density and then dividing by the area of the sample (200,000 cm^2). The cover was converted to a percent by multiplying by 100. For the trees and shrubs taller than 1.83m, the dbh was measured at the standard 1.37m height using a diameter tape and recorded to the nearest 0.1 cm. The woody plant data in the sixty samples were recorded in the fall only while the herbaceous plant data were recorded in the fall and again in the spring. To facilitate relocation of plots, a metal pin was left in the center of the stream until the re-sampling was completed.

All data were entered into a Microsoft Excel spread sheet for storage and calculation of variables. The mean diversity (richness-species per sample) and mean density (stems per sample) were calculated for the samples in each group (upstream or downstream) for all plant categories while the mean dbh was calculated for trees and shrubs and mean cover percent was calculated for herbaceous plants, woody vines, and shrubs and saplings. The frequency and mean density were calculated for each species in a sample group. The mean dbh was calculated for tree and shrub species and the mean cover percent for all other species in a sample group. The relative values for each of these variables (frequency, mean density, mean dbh, and mean cover percent) were calculated by dividing the value for a species by the total for all species within the sample group and plant category. Each value was converted to a percent by multiplying by 100 and the sum of these relative values was used to calculate the importance value.

RESULTS

The number of species in the upstream area with yellow root totaled 122 and contained 24 trees and shrubs, 50 shrubs and saplings, 13 woody vines, and 57 herbaceous plants (Table 1). The number of species in the downstream area without yellow root totaled 69 with 15 trees and shrubs, 34 shrubs and saplings, 9 woody vines; and 25 herbaceous plants. In the upstream area, the mean number of species per sample ranged from 3.44 for trees and shrubs to 14.92 for shrubs and saplings while in the downstream study area the mean number of species per sample ranged from 4.10 for trees and shrubs to 14.40 for shrubs and saplings. In the upstream area where yellow root was present, the mean density ranged from 7.12 stems for trees and shrubs to 92.10 for

TABLE 1. Species diversity (richness) of samples in the upstream area with yellow root and downstream without yellow root at Fort Polk, Louisiana.

	Yellow root Present (Upstream, 50 samples)				
	All Plants	Trees & Shrubs	Shrubs & Saplings	Woody Vines	Herbaceous Plants
Mean	33.34	3.44	14.92	5.26	12.32
Std Dev.	5.93	1.62	2.97	1.66	3.62
Total Number	122	24	50	13	57
	Yellow root Absent (Downstream, 10 samples)				
	All Plants	Trees & Shrubs	Shrubs & Saplings	Woody Vines	Herbaceous Plants
Mean	31.10	4.10	14.40	6.10	9.80
Std Dev.	3.84	0.99	1.96	0.88	2.39
Total Number	69	15	34	9	25

TABLE 2. Community physiognomy variables (density, cover percent, and DBH) of samples in the yellow root area and just downstream at Fort Polk, Louisiana.

	Yellow root Present (Upstream) Density (stems per sample), 50 samples				
	All Plants	Trees & Shrubs	Shrubs & Saplings	Woody Vines	Herbaceous Plants
Mean	207.06	7.12	92.10	19.48	88.36
Std Dev.	65.36	5.15	26.50	11.13	51.91
	Yellow root Absent (Downstream) Density (stems per sample), 10 samples				
	All Plants	Trees & Shrubs	Shrubs & Saplings	Woody Vines	Herbaceous Plants
Mean	149.60	9.80	55.90	33.70	50.20
Std Dev.	30.29	8.11	15.46	10.90	14.16
	Yellow root Present (Upstream) 50 samples Cover Percent & DBH (cm)				
	All Plants	Shrubs & Saplings	Woody Vines	Herbaceous Plants	Trees & Shrubs
Mean	7.13	4.48	0.50	2.15	36.35
Std Dev.	2.04	1.89	0.65	1.14	29.40
	Yellow root Absent (Downstream) 10 samples Cover Percent & DBH (cm)				
	All Plants	Shrubs & Saplings	Woody Vines	Herbaceous Plants	Trees & Shrubs
Mean	6.15	2.85	1.90	1.40	34.02
Std Dev.	2.34	1.06	1.29	0.61	22.01

shrubs and saplings. The downstream area, without yellow root, had a mean density range from 9.80 stems for trees and shrubs to 55.90 stems for shrubs and saplings (Table 2). In the upstream area, the mean cover percent ranged from 0.50% for woody vines to 4.48% for shrubs and saplings and in the downstream area the mean cover percent ranged from 1.40% for herbaceous plants to 2.85% for shrubs and saplings. In the upstream area, the mean density for all plants was 207.06 stems and the mean cover percent was 7.13% compared to a mean density of 149.60 stems and mean cover percent of 6.15% in the downstream area. The mean dbh was 36.35 cm for the trees and shrubs in the 50 samples upstream and 34.02 cm for the 10 samples downstream.

The frequency, mean density, mean cover percent, and importance value for the herbaceous plants in the area of yellow root are in Table 3 and the data for the same group of species in the area just downstream from yellow root are in Table 4. The similar data for the woody vines in the area of yellow root are in Table 5 and for the shrub and sapling species in Table 7. The similar data for the woody vines in the area just downstream from yellow root are in Table 6 and for the shrub and sapling species in Table 8. The frequency, mean density, mean dbh, and importance value for the trees and shrubs in the upstream area are in Table 9 and the data for this

TABLE 3. Frequency, mean density, mean cover percent, and importance value for herbaceous plants in 50 samples with yellow root (upstream) at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Chasmanthium laxum	98.00	11.60	0.40	39.53
Mitchella repens	96.00	11.12	0.41	39.28
Dichanthelium commutatum	96.00	12.98	0.23	33.13
Viola primulifolia	86.00	16.44	0.01	26.16
Dichanthelium dichotomum	88.00	7.82	0.13	22.19
Osmunda cinnamomea	64.00	2.40	0.27	20.65
Scleria oligantha	82.00	3.28	0.20	19.71
Osmunda regalis	46.00	1.94	0.13	12.11
Athyrium felix-femina	60.00	2.38	0.05	9.69
Carex spp.	58.00	1.54	0.03	8.06
Solidago patula	44.00	2.66	0.01	7.08
Aster lateriflorus	38.00	1.12	0.03	5.97
*Apteria aphylla**	32.00	2.48	0.00	5.41
Panicum verrucosum	30.00	2.34	0.00	5.25
Rhynchospora charlocephala	24.00	0.80	0.04	4.78
*Solidago caesia**	28.00	1.46	0.01	4.42
Carex glaucescens	20.00	0.32	0.03	3.26
*Panicum rigidulum**	12.00	0.38	0.04	3.23
Dichanthelium sphaerocarpon	20.00	0.42	0.02	3.14
*Dichanthelium aciculare**	20.00	0.82	0.01	3.09
*Xyris ambigua**	30.00	0.42	0.00	3.05
Solidago rugosa	14.00	0.42	0.00	1.79
*Woodwardia virginica**	4.00	0.32	0.02	1.64
*Eupatorium fistulosum**	12.00	0.20	0.00	1.41
Elephantopus nudatus	12.00	0.20	0.00	1.37
Eupatorium rotundifolium	12.00	0.22	0.00	1.29
*Pteridium aquilinum**	10.00	0.18	0.00	1.13
Xyris difformis var. *curtisii*	10.00	0.18	0.00	1.03
*Arnoglossum ovatum**	6.00	0.28	0.00	0.92
*Rhynchospora inexpansa**	4.00	0.12	0.01	0.76
Woodwardia aereolata	4.00	0.28	0.00	0.76
*Schizachyrium scoparium**	6.00	0.10	0.00	0.74
*Scuttelaria integrifolia**	6.00	0.10	0.00	0.64
Aristida purpurascens var. *virgata**	4.00	0.04	0.01	0.62
Chasmanthium latifolium	2.00	0.12	0.01	0.60
*Lycopus rubellus**	4.00	0.20	0.00	0.57
*Melanthium virginicum**	4.00	0.06	0.00	0.51
*Liatris pychnostachya**	4.00	0.06	0.00	0.43
Centella erecta	4.00	0.08	0.00	0.42
*Hypoxis hirsuta**	4.00	0.04	0.00	0.39
*Dichanthelium tenue**	2.00	0.06	0.00	0.33
*Carex intumescens**	2.00	0.02	0.00	0.28
*Helianthus angustifolius**	2.00	0.02	0.00	0.24
*Platanthera ciliaris**	2.00	0.02	0.00	0.23
*Dichanthelium laxiflorum**	2.00	0.04	0.00	0.22
*Rhexia virginica**	2.00	0.04	0.00	0.22
*Axonopus fissifolius**	2.00	0.02	0.00	0.22
*Oxypolis rigidior**	2.00	0.02	0.00	0.21
*Oldenlandia boscii**	2.00	0.04	0.00	0.21
*Eupatorium perfoliatum**	2.00	0.02	0.00	0.21
*Eupatorium capillifolium**	2.00	0.02	0.00	0.21
*Hyptis alata**	2.00	0.02	0.00	0.21
*Panicum brachyanthum**	2.00	0.02	0.00	0.20
*Coreopsis tripteris**	2.00	0.02	0.00	0.20
Lobelia puberula	2.00	0.02	0.00	0.19
*Ludwigia mariana**	2.00	0.02	0.00	0.19
*Conyza canadensis**	2.00	0.02	0.00	0.19
Total	**1232.00**	**88.36**	**2.15**	**300.00**

* Only in the upstream samples with yellow root.

TABLE 4. Frequency, mean density, mean cover percent, and importance value for herbaceous plants in 10 samples in the area just downstream from yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Chasmanthium laxum	100.00	19.10	0.63	93.14
Mitchella repens	100.00	6.40	0.32	45.54
Scleria oligantha	90.00	2.50	0.18	27.24
Dichanthelium commutatum	100.00	5.00	0.06	24.32
Dichanthelium dichotomum	90.00	2.90	0.04	17.66
Viola primulifolia	60.00	5.50	0.01	17.45
Athyrium felix-femina	80.00	2.50	0.01	13.87
Carex spp.	70.00	1.80	0.02	12.44
Osmunda cinnamomea	20.00	0.50	0.07	7.81
Panicum verrucosum	50.00	0.80	0.01	7.09
Aster lateriflorus	30.00	0.80	0.01	5.01
Woodwardia areolata	30.00	0.30	0.01	4.02
Osmunda regalis	20.00	0.30	0.02	4.00
*Botrychium biternatum**	20.00	0.20	0.00	2.46
Eupatorium rotundifolium	20.00	0.20	0.00	2.45
Solidago rugosa	10.00	0.30	0.01	2.15
Lobelia puberula	10.00	0.20	0.01	2.07
Carex glaucescens	10.00	0.10	0.01	1.97
Dichanthelium sphaerocarpon	10.00	0.20	0.00	1.46
Rhynchospora charlocephala	10.00	0.10	0.00	1.44
Solidago patula	10.00	0.10	0.00	1.36
Elephantopus nudatus	10.00	0.10	0.00	1.30
*Dichanthelium boscii**	10.00	0.10	0.00	1.27
Centella erecta	10.00	0.10	0.00	1.24
Xyris difformis var. *curtisii*	10.00	0.10	0.00	1.23
Total	**980.00**	**50.20**	**1.40**	**300.00**

* Only in downstream samples without yellow root.

TABLE 5. Frequency, mean density, mean cover percent, and importance value for woody vines in 50 samples in the area of yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Vitis rotundifolia	46.00	1.18	0.17	48.39
Smilax glauca	74.00	4.20	0.06	47.82
Gelsemium sempervirens	70.00	2.68	0.07	40.71
Smilax rotundifolia	68.00	2.88	0.07	40.70
Smilax pumila	40.00	2.72	0.05	31.92
Bignonia capreolata	60.00	2.40	0.02	28.24
Smilax laurifolia	48.00	0.96	0.03	19.33
Smilax smallii	48.00	0.88	0.02	18.07
*Toxicodendron radicans**	34.00	0.84	0.00	11.77
Rubus argutus	20.00	0.44	0.00	6.69
*Smilax bona-nox**	12.00	0.24	0.01	4.80
*Parthenocissus quinquefolia**	4.00	0.04	0.00	1.03
*Berchemia scandens**	2.00	0.02	0.00	0.51
Total	**526.00**	**19.48**	**0.50**	**300.00**

* Only in the upstream samples with yellow root.

TABLE 6. Frequency, mean density, mean cover percent, and importance value for woody vines in 10 samples in the area just downstream from yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Vitis rotundifolia	90.00	9.50	0.95	93.28
Smilax glauca	100.00	8.90	0.23	55.06
Smilax rotundifolia	90.00	3.50	0.31	41.48
Smilax pumila	70.00	3.70	0.31	38.55
Bignonia capreolata	90.00	4.40	0.02	28.82
Smilax smallii	70.00	1.40	0.02	16.52
Gelsemium sempervirens	50.00	0.80	0.04	12.80
Smilax laurifolia	40.00	0.90	0.01	9.51
Rubus argutus	10.00	0.60	0.01	3.97
Total	**610.00**	**33.70**	**1.90**	**300.00**

group of species in the downstream area are in Table 10. The species are arranged in descending importance value in all eight tables.

The two herbaceous species with the highest importance value in both areas were *Chasmanthium laxum* (L.) Yates and *Mitchella repens* L. but the importance value for *Chasmanthium laxum* (L.)Yates was much higher in the downstream area (93.14) than in the upstream area(39.53) (Tables 3 and 4). The third species in the area of yellow root was *Dichanthelium commutatum* (Schult.) Gould and in the area just downstream was *Scleria oligantha* Michx. The top two species in importance value among the woody vines in both areas were *Vitis rotundifolia* Michx. and *Smilax glauca* Walter but the importance value for *Vitis rotundifolia* in the upstream area was much higher (93.28) compared to a value of 48.39 in the downstream area (Tables 5 and 6). The third species in importance value in the area of yellow root was *Gelsemium sempervirens* (L.) W.T. Aiton and in the area just downstream from yellow root was *Smilax rotundifolia L.* In the upstream area, the shrub and sapling species with the highest important value was *Lyonia lucida* (Lam.) K. Koch and was followed by *Ilex coriacea* (Pursh) Chapm. and *Vaccinium elliottii* Chapm. (Table 7). In the downstream area, the shrub and sapling species with the highest importance value was *Vaccinium elliottii* Chapm. and was followed by *Halesia diptera* Ellis *Hypericum hypericoides* (L.) Crantz, and *Symplocos tinctoria* (L.) L'Her. (Table 8). The tree and shrub species with the highest importance value in the area of yellow root was *Ilex coriacea* (Pursh) Chapm. , followed by *Magnolia virginiana* L., *Nyssa biflora* Walter, and *Vaccinium elliottii* Chapm. (Table 9). The tree and shrub species with the highest importance value in the area downstream from yellow root was *Vaccinium elliottii* Chapm., followed by *Acer rubrum* L. and *Nyssa biflora* Walter (Table 10).

Thirty-three herbaceous species were found only upstream in the area containing yellow root (Table 3). Two herbaceous species were found only downstream in the area without yellow root (Table 4). All other herbaceous species were found in both upstream and downstream samples (Tables 3 and 4). Four woody vine species were found only upstream with yellow root (Table 5). No vine species were unique to the downstream samples. All other woody vine species were found in both upstream and downstream samples (Tables 5 and 6). Twenty-two shrub and sapling species were found only upstream with yellow root (Table 7) and six shrub and sapling species were found only downstream without yellow root (Table 8). All other shrub and sapling species were found in both upstream and downstream samples (Tables 7 and 8). Twelve tree and shrub species were found only upstream with yellow root (Table 9) and three trees and shrub species were found only downstream (Table 10). All other tree and shrub species were found in both upstream and downstream samples (Tables 9 and 10).

DISCUSSION

The yellow root habitat in Louisiana is best described as the bank and natural levee of a baygall stream with the vegetation being typical of such a stream. We found the tree canopy vegetation associated with yellow root to

TABLE 7. Frequency, mean density, mean cover percent, and importance value for shrubs and saplings in 50 samples in yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Lyonia lucida	98.00	25.48	2.11	81.42
*Ilex coriacea**	88.00	7.92	0.75	31.27
Vaccinium elliotii	98.00	6.74	0.50	25.12
Rhododendron canescens	98.00	8.66	0.14	19.18
Acer rubrum	98.00	7.72	0.04	15.83
*Hypericum hypericoides**	90.00	5.98	0.12	15.10
Halesia diptera	66.00	2.04	0.20	11.04
Persea palustris	76.00	2.58	0.11	10.34
Quercus hemisphaerica	70.00	4.14	0.03	9.78
Pinus taeda	72.00	2.54	0.02	8.06
Quercus alba	66.00	2.42	0.02	7.41
*Xanthorhiza simplicissima**	38.00	3.62	0.03	7.07
Ilex vomitoria	46.00	0.98	0.06	5.45
Hamamelis virginiana	36.00	1.48	0.06	5.29
*Magnolia virginiana**	42.00	0.88	0.04	4.69
Symplocos tinctoria	20.00	1.10	0.09	4.54
Ilex opaca	28.00	0.64	0.02	3.03
Morella cerifera	22.00	0.86	0.02	2.91
*Morella heterophylla**	24.00	0.56	0.02	2.62
Nyssa biflora	26.00	0.54	0.00	2.41
Liquidambar styraciflua	24.00	0.38	0.00	2.12
Quercus laurifolia	24.00	0.36	0.00	2.05
*Viburnum nudum**	20.00	0.38	0.00	1.85
Itea virginica	18.00	0.48	0.00	1.84
*Alnus serrulata**	18.00	0.30	0.01	1.75
*Callicarpa americana**	18.00	0.20	0.00	1.53
Vaccinium virgatum	8.00	0.48	0.02	1.52
*Cyrilla racemiflora**	12.00	0.38	0.01	1.47
Euonymus americanus	14.00	0.24	0.00	1.22
*Quercus nigra**	14.00	0.22	0.00	1.20
*Photinia pyrifolia**	12.00	0.30	0.00	1.16
Quercus falcata	12.00	0.12	0.01	1.14
Sassafras albidum	14.00	0.14	0.00	1.11
Chionanthus virginicus	10.00	0.16	0.00	0.95
*Cornus florida**	12.00	0.12	0.00	0.94
Vaccinium arboreum	10.00	0.14	0.01	0.94
*Styrax grandifolius**	8.00	0.26	0.00	0.89
*Hypericum crux-andreae**	8.00	0.18	0.01	0.85
Viburnum dentatum	8.00	0.08	0.00	0.65
Prunus serotina	6.00	0.10	0.00	0.53
*Castanea pumila**	2.00	0.02	0.00	0.22
Arundinaria gigantea	2.00	0.02	0.00	0.19
*Fagus grandifolia**	2.00	0.02	0.00	0.18
*Vaccinium fuscatum**	2.00	0.02	0.00	0.18
*Toxicodendron vernix**	2.00	0.02	0.00	0.18
*Pinus palustris**	2.00	0.02	0.00	0.17
*Cephalanthus occidentalis**	2.00	0.02	0.00	0.16
*Quercus stellata**	2.00	0.02	0.00	0.16
*Sapium sebiferum**	2.00	0.02	0.00	0.16
Prunus mexicana	2.00	0.02	0.00	0.16
Total	**1492.00**	**92.10**	**4.48**	**300.00**

* Only in upstream samples with yellow root.

be *Magnolia virginiana* L., *Nyssa biflora* Walter, and *Liquidambar styraciflua* L. The canopy with the shrub layer being *Lyonia lucida* (Lam.) K. Koch, *Ilex coriacea* (Pursh) Chapm., and *Vaccinium elliottii* Chapm. These species are very similar to the woody species reported for baygalls in the area by Allen et al. in 2004, in east Texas by

TABLE 8. Frequency, mean density, mean cover percent, and importance value for shrubs and saplings in 10 samples just downstream from yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Vaccinium elliotii	100.00	12.80	1.29	75.05
Halesia diptera	100.00	3.80	0.23	21.90
*Hypericum hypericoides**	100.00	5.30	0.14	21.32
Symplocos tinctoria	60.00	4.30	0.26	20.98
Arundinaria gigantea	60.00	3.30	0.19	16.68
Rhododendron canescens	100.00	3.60	0.09	16.51
Acer rubrum	90.00	3.60	0.05	14.44
Quercus hemisphaerica	100.00	3.40	0.02	13.90
Hamamelis virginiana	50.00	3.20	0.08	12.11
Lyonia lucida	30.00	1.90	0.15	10.82
Ilex vomitoria	60.00	1.40	0.09	9.77
Nyssa biflora	70.00	1.00	0.00	6.75
Vaccinium virgatum	40.00	1.10	0.06	6.69
Ilex opaca	50.00	0.90	0.04	6.58
Quercus falcata	60.00	0.90	0.01	6.13
Itea virginica	30.00	0.80	0.06	5.47
Pinus taeda	50.00	0.60	0.01	4.85
Prunus serotina	30.00	0.50	0.01	3.17
Viburnum dentatum	20.00	0.70	0.01	3.13
Persea palustris	30.00	0.40	0.01	3.12
Liquidambar styraciflua	30.00	0.40	0.00	2.95
Quercus alba	30.00	0.30	0.01	2.83
*Amelanchier arborea**	30.00	0.30	0.00	2.64
*Magnolia virginiana**	20.00	0.30	0.00	2.08
Crataegus marshallii	10.00	0.10	0.03	1.82
Sassafras albidum	10.00	0.20	0.00	1.20
Vaccinium arboreum	10.00	0.10	0.00	0.91
*Carya texana**	10.00	0.10	0.00	0.90
Quercus laurifolia	10.00	0.10	0.00	0.90
Prunus mexicana	10.00	0.10	0.00	0.89
Chionanthus virginicus	10.00	0.10	0.00	0.89
*Ulmus alata**	10.00	0.10	0.00	0.88
Morella cerifera	10.00	0.10	0.00	0.88
Euonymus americanus	10.00	0.10	0.00	0.88
Total	**1440.00**	**55.90**	**2.85**	**300.00**

* Only in downstream samples without yellow root.

Diggs et al. 2006 and in central Louisiana by MacRoberts et al. 2004. The herbaceous flora associated with yellow root in our area is dominated by *Chasmanthium laxum* (L.) Yates, *Mitchella repens* L., and *Dichanthelium commutatum* (Schult.) Gould; three species that have been noted by the senior author to be shade tolerant. Our data seem to verify the qualitative reports of the shaded stream bank, small stream bank, and moist woods habitat for yellow root. Yellow root was found in 19 of the 50 samples and had an importance value of 7.07 out of 300 and was the 12th ranked shrub in importance value.

In the downstream samples, the vegetation contains species that are usually associated with less wet or more mesic to dry sites. Red maple (*Acer rubum* L.) and southern red oak (*Quercus falcata* Michx.) are two tree species with high importance values in the downstream samples and are usually found on more mesic sites. An herbaceous species (*Scleria oligantha* Michx.) is usually associated with mesic sites as are the shrub species *Halesia diptera* Ellis, *Hypericum hypericoides* (L.) Crantz, and *Symplocos tinctoria* (L.) L'Her. The dominance of these species downstream and the absence of yellow root seem to indicate that yellow root cannot tolerate the more mesic downstream sites. The big community difference in the downstream samples was the decrease in herbaceous plants (richness, density, and cover percent). The mean density and cover percent also decreased

TABLE 9. Frequency, mean density, mean cover percent, and importance value for trees and shrubs in 50 samples in the area of yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Ilex coriacea	56.00	2.30	3.70	58.75
*Magnolia virginiana**	32.00	0.62	3.67	28.11
Nyssa biflora	26.00	0.36	4.19	24.15
Vaccinium elliotii	34.00	0.72	1.26	23.47
Liquidambar styraciflua	22.00	0.22	3.62	19.45
Halesia diptera	26.00	0.42	1.74	18.24
*Quercus alba**	16.00	0.18	3.84	17.74
*Persea palustris**	24.00	0.30	1.93	16.51
Acer rubrum	20.00	0.28	1.83	14.78
*Pinus taeda**	8.00	0.10	3.92	14.51
*Hamamelis virginiana**	14.00	0.44	1.01	13.04
Lyonia lucida	20.00	0.38	0.40	12.26
Ilex vomitoria	6.00	0.20	0.75	6.61
*Cornus florida**	4.00	0.08	0.93	4.84
Rhododendron canescens	6.00	0.14	0.21	4.29
*Quercus hemisphaerica**	4.00	0.04	0.81	3.95
Ilex opaca	4.00	0.10	0.44	3.77
*Fagus grandifolia**	6.00	0.06	0.27	3.32
*Quercus nigra**	2.00	0.02	0.81	3.09
*Alnus serrulata**	6.00	0.06	0.07	2.77
Quercus falcata	2.00	0.02	0.50	2.24
*Magnolia grandiflora**	2.00	0.04	0.38	2.19
*Crataegus marshallii**	2.00	0.02	0.04	0.97
*Symplocos tinctoria**	2.00	0.02	0.03	0.94
Total	**344.00**	**7.12**	**36.35**	**300.00**

* Only in upstream samples with yellow root.

TABLE 10. Frequency, mean density, mean cover percent, and importance value for trees and shrubs in 10 samples just downstream from yellow root at Fort Polk, Louisiana.

Species	Frequency	Mean Density	Mean cover%	Importance Value
Vaccinium elliotii	80.00	4.10	5.72	77.70
Acer rubrum	80.00	1.10	7.70	52.91
Nyssa biflora	40.00	0.60	9.13	42.48
Quercus falcata	20.00	0.10	4.08	17.78
Rhododendron canescens	30.00	0.60	1.33	17.17
Ilex vomitoria	30.00	0.60	1.02	16.26
Lyonia lucida	10.00	0.70	0.76	11.76
Halesia diptera	30.00	0.30	0.52	11.73
Ilex coriacea	10.00	0.70	0.70	11.58
Ilex opaca	20.00	0.20	0.65	8.71
*Arundinaria gigantea**	20.00	0.30	0.14	8.23
Crataegus marshallii	20.00	0.20	0.28	7.63
Liquidambar styraciflua	10.00	0.10	1.27	7.13
*Vaccinium arboreum**	10.00	0.10	0.47	4.78
*Amelanchier arborea**	10.00	0.10	0.25	4.14
Total	**420.00**	**9.80**	**34.02**	**300.00**

* Only in downstream samples without yellow root.

downstream for shrubs and saplings while increasing for woody vines. The lack of yellow root and these changes in the community seem to indicate a more mesic site created by a larger stream that produces a higher and thus more mesic natural levee.

Our data are the first quantitative report on the vegetation surrounding *Xanthorhiza simplicissima* Marsh. The vegetation around the other populations of *Xanthorhiza simplicissima* Marsh. throughout its range should be sampled for comparison with our data so as to get a better idea of the variation, if any, of its habitat.

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VASCULAR FLORA AND PLANT COMMUNITIES OF ALLEGHANY COUNTY, NORTH CAROLINA

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ABSTRACT

An inventory of the vascular plant species of Alleghany County, North Carolina was conducted from spring 2008–summer 2012. Extensive fieldwork was augmented by a search of numerous herbaria, resulting in the documentation of 1508 taxa (1457 species) in 642 genera and 161 families. These taxa are represented by nine Lycopodiophyta, 39 Monilophyta, 23 Acrogymnospermae, and 1437 Angiospermae. Four hundred and thirty-five taxa, 28.8% of the total flora, are considered exotic. Sixty-five native taxa have state or global ranking due to rarity. Ten species are documented here as new to the flora of North Carolina, while 613 are new county distributional records. An additional 38 plausible sight records are included in the annotated checklist to bring attention to their uncertain attribution to the flora; however, these records are not treated in the taxonomic summary. A comparative assessment of all plant origin categories (i.e., native vs. multiple exotic categories) within the flora is included to accommodate the various perspectives of the botanical community. A companion website (www.vascularflora.appstate.edu) was created to provide a dynamic source of digital documentation for this study.

RESUMEN

Se realizó un inventario de las especies de plantas vasculares del condado de Alleghany, Carolina del Norte desde la primavera de 2008 hasta el verano de 2012. El extensivo trabajo de campo de Incrementó con la búsqueda en numerosos herbarios, dando como resultado la documentación de 1508 taxa (1457 especies) en 642 géneros y 161 familias. Estos taxa están representados por 9 Lycopodiophyta, 39 Monilophyta, 23 Acrogymnospermae, 1437 Angiospermae. 435 taxa, 28.8% de la flora total, están consideradas exóticas. 65 taxa nativos están considerados como amenazados a nivel estatal o global debido a su rareza. Se documentan 10 especies como nuevas para la flora de Carolina del Norte, mientras que 613 son citas de distribución en nuevos condados. Se incluyen 38 citas de visu adicionales plausibles en el catálogo anotado para atraer la atención sobre su atribución a la flora; sin embargo, estas citas no se tratan en el resumen taxonómico. Se incluye una evaluación comparativa de las categorías de origen de todas las plantas (ej., nativas vs. múltiples categorías de exóticas) se incluye en la flora para acomodar las diferentes perspectivas de la comunidad botánica. Se ha creado una página web (www.vascularflora.appstate.edu) para aportar una fuente dinámica de documentación digital para este estudio.

INTRODUCTION

Perhaps the most intense effort to document county floras in North Carolina and South Carolina was during the production of the regionally renowned *Manual of the Vascular Flora of the Carolinas* (Radford et al. 1968). This manual was the product of many years of botanical exploration within these contiguous states and its impact was far reaching. It served and continues to serve as a mainstay of taxonomic reference for the flora of this area, and has been made extensible to neighboring states for various studies. However, there are limitations to how much a single, large-scope work can cover regarding the mammoth task of documenting plant distributions. Consequently, few if any counties within the range of Radford et al.'s (1968) original manual can be considered "comprehensively inventoried". Likewise, since its publication much time has passed. Taxonomic revisions, new discoveries, and novel exotic introductions have occurred, thus necessitating a new treatment (e.g., Weakley 2011). In light of global climate change, undiscovered new taxa, an evolving knowledge of vegetation patterns and modern techniques for cataloguing plant diversity data, there is a pervasive and revived need for continued floristic research.

The objectives of this descriptive study were to: 1) document and georeference specimens of the known vascular flora of Alleghany County, North Carolina; 2) describe general plant communities; 3) analyze the flora

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in context of species richness and origin (i.e., native vs. multiple exotic categories) of taxa; and 4) make voucher data digitally available via a web interface to the botanical and general communities.

THE STUDY SITE

Physiography

Alleghany County, North Carolina is located in the northwest corner of the state, between 36.36° and 36.57°N latitude, and 80.91° and 81.35°W longitude (Fig. 1). The county is the 4th smallest in North Carolina, with a total area of 610 km^2, comprised of 607.7 km^2 of land and 2.3 km^2 water (United States Census Bureau [USCB] 2011a). It is bordered by Surry County to the east, Wilkes County to the south, Ashe County to the west, and Grayson County, Virginia to the north (Fig. 2). The southern and eastern boundary of the county is close to the rim of the Blue Ridge Escarpment and comprises part of the Eastern Continental Divide. This county contains two major river basins, the New River Basin and the Upper Yadkin River Basin. Most tributaries (e.g., Little River, Prathers Creek) in Alleghany County empty into the New River, which ultimately drains into the Gulf of Mexico via the Ohio and Mississippi Rivers. The tributaries associated with the New River watershed drain ca. 93–95% of the county (Padgett 2011). The far southern and eastern portions of Alleghany are the only exception, with relatively few tributaries (e.g., Mitchell River headwaters) draining off of the escarpment into the Upper Yadkin River Basin and eventually emptying into the Atlantic Ocean.

Alleghany County is principally montane. It is located within the Southern Section of the Blue Ridge Physiographic Province (Fenneman 1938) of the Southern Appalachians (Braun 1950), although a small fraction of the southeastern boundary is situated just below the Blue Ridge Escarpment (in the vicinity of Stone Mountain State Park) in the Piedmont Upland Physiographic Province (Fenneman 1938). Topographic variation increases dramatically as the western and northern portions of the county grade into typical high to mid-elevation mountain ridges that are more characteristic of this region (Fig. 2). This physiognomy of the landscape differs somewhat from the highest mountains in northwest North Carolina, which are exemplified by the Amphibolite Mountains Macrosite to the west of Alleghany County in adjacent Ashe and Watauga Counties. Many of the peaks in that area exceed 1500 m in elevation, and possess a prominent northern floristic component typically associated with the inner, high mountains of the Blue Ridge. In contrast, the highest elevation in Alleghany County is Catherine Knob (1272 m), which is part of a chain of peaks that run diagonally northeast through the upper third of the county and contains several other notable peaks (Fender Mountain, 1213 m; Cheek Mountain, 1201 m; Twin Oaks Mountain, 1116 m; and Bald Knob, 1109 m). In addition, there are several outliers to the south and southeast (e.g., Bullhead Mountain, 1171 m; Bluff Mountain, 1139 m; Mahogany Rock, 1103 m; and Green Mountain, 1018 m) that occur primarily adjacent to the edge of the Blue Ridge Escarpment (Fig. 2). Though most of the lower elevation areas in the county occur within the New River drainage and headwaters of the Mitchell River, the minimum elevation occurs around the foot of Stone Mountain (475 m) along the Wilkes County border. Ultimately, this difference in geography and topography, as compared to the predominately higher elevations westward, results in a small reduction in the presence of northern species, but in turn adds some lower elevation species with Piedmont affinities to the vegetation of the county.

Braun (1950) broadly classified the vegetation of Southern Appalachians as a part of the Oak-Chestnut Forest Region, but this area is now more appropriately referred to as the Appalachian Oak Forest Region (Küchler 1964; Stephenson 1993) following the demise of the American chestnut. Despite these general regional classifications, vegetation patterns in Alleghany County are largely a consequence of its highly variable landscape and hydrology that contribute to a wide array of communities including both forested areas and wetlands.

Climate

The continental climate of the southern Appalachians is temperate, humid mesothermal, lacking a distinct dry season (precipitation shows only minor fluctuation), cool to warm summers, and mild to cold winters (Trewartha & Horn 1980). Alleghany County has a wide range of microclimate variation related to its mountainous terrain. Due to incomplete data from the Sparta weather station, Alleghany County climate normals (1971–

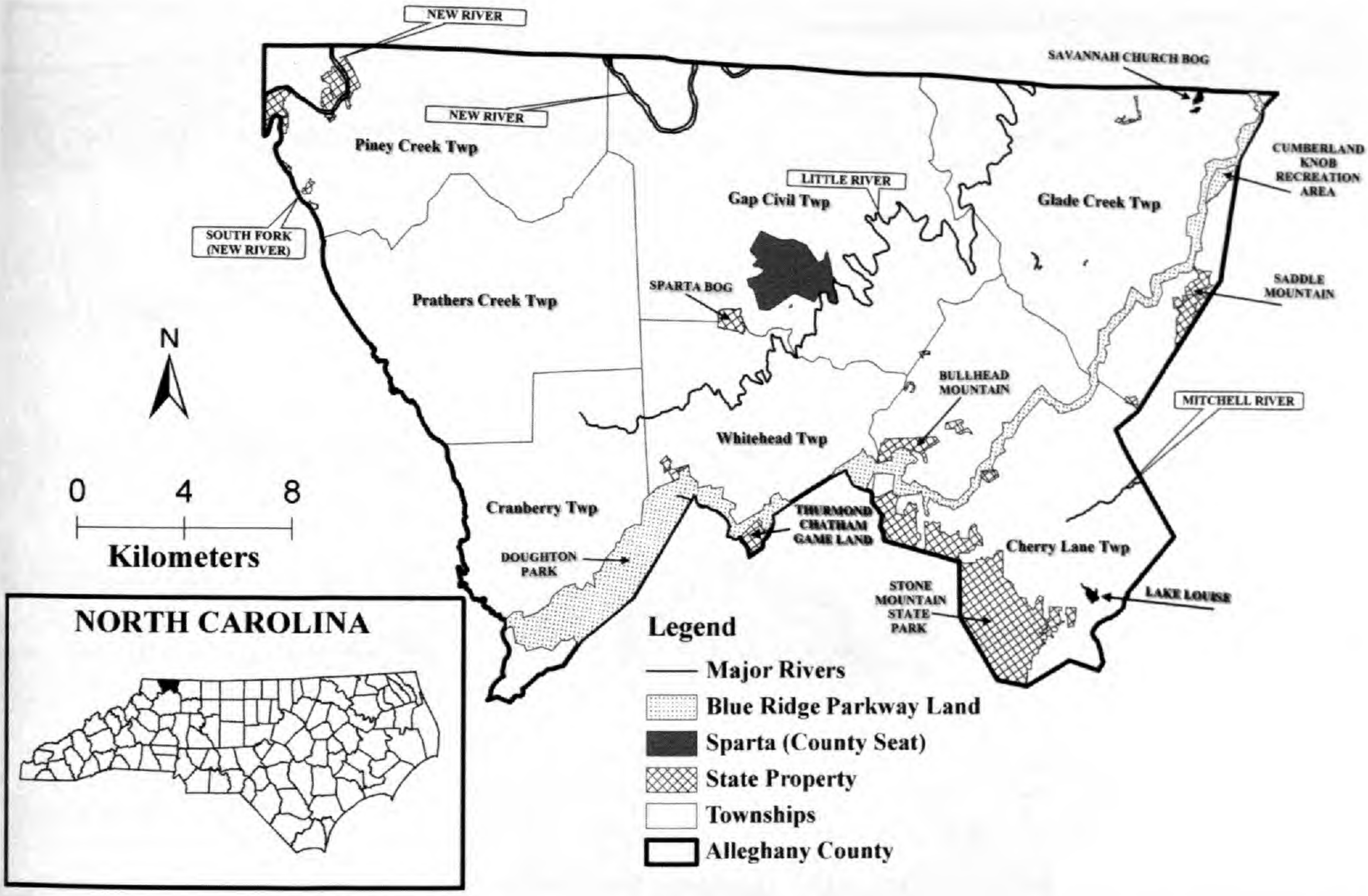


Fig. 1. Map of Alleghany County divided into townships and displaying major river systems, and State and Federally owned lands.

2000) are derived from the Transou weather station in Laurel Springs, Ashe County, located approximately 4.1 km southwest of the Alleghany County line at 36.39°N latitude, 81.30°W longitude, and 876 m elevation. Mean annual precipitation is 144.0 cm with March the highest at 14.2 cm and December the lowest at 9.2 cm, while the mean annual snowfall (based on data from 1946–2009) for this area is 57.9 cm. The mean annual temperature of this area is 9.4°C, with January the coldest month, averaging -1.2°C and July the warmest month at 19.9°C (Southeast Regional Climate Center 2011). Based on data at Transou weather station from 1951–1980, the average length of the growing season is 139 days (Perry 1998a), with the average first fall frost on October 1, and the last spring frost on May 15 (Perry 1998b).

Geology

The geology of the southern Appalachians is a result of a complex history of metamorphism and erosion (Williams 1979; Abbott and Raymond 1984), which is directly responsible for the mosaic of vegetation patterns that occur within this mountain range. Consequently, Alleghany County exhibits a multifaceted geology (Fig. 3) associated with four separate alliances: the Alligator Back Formation, Ashe Formation, Elk Park Plutonic Group, and Spruce Pine Plutonic Group (Rankin et al. 1972; Epenshade et al. 1975; Williams 1979). Most parent material in the county is characterized by the first two metamorphic formations, both of which contain bands of mafic rock, while the latter two groups contribute a less abundant intrusive metamorphosed/igneous component to the bedrock of the area. Mafic rock (amphibolite) is uncommon in the county and is directly associated with rare plant assemblages. Likewise, ultramafic rock, which is also responsible for idiosyncratic vegetation patterns is very rare and localized and will be discussed independently.

The Alligator Back Formation occupies the southeastern third of the county. It is horizontally oriented, running from Laurel Springs northeast to Edmonds. This metamorphic formation is of Precambrian and/or Paleozoic (late Proterozoic) origin. It is primarily comprised of gneiss, with quartzo-feldspathic layers, thin mica, thicker areas of schist, some phyllite, amphibolite and greenstone. Some smaller areas within this forma-

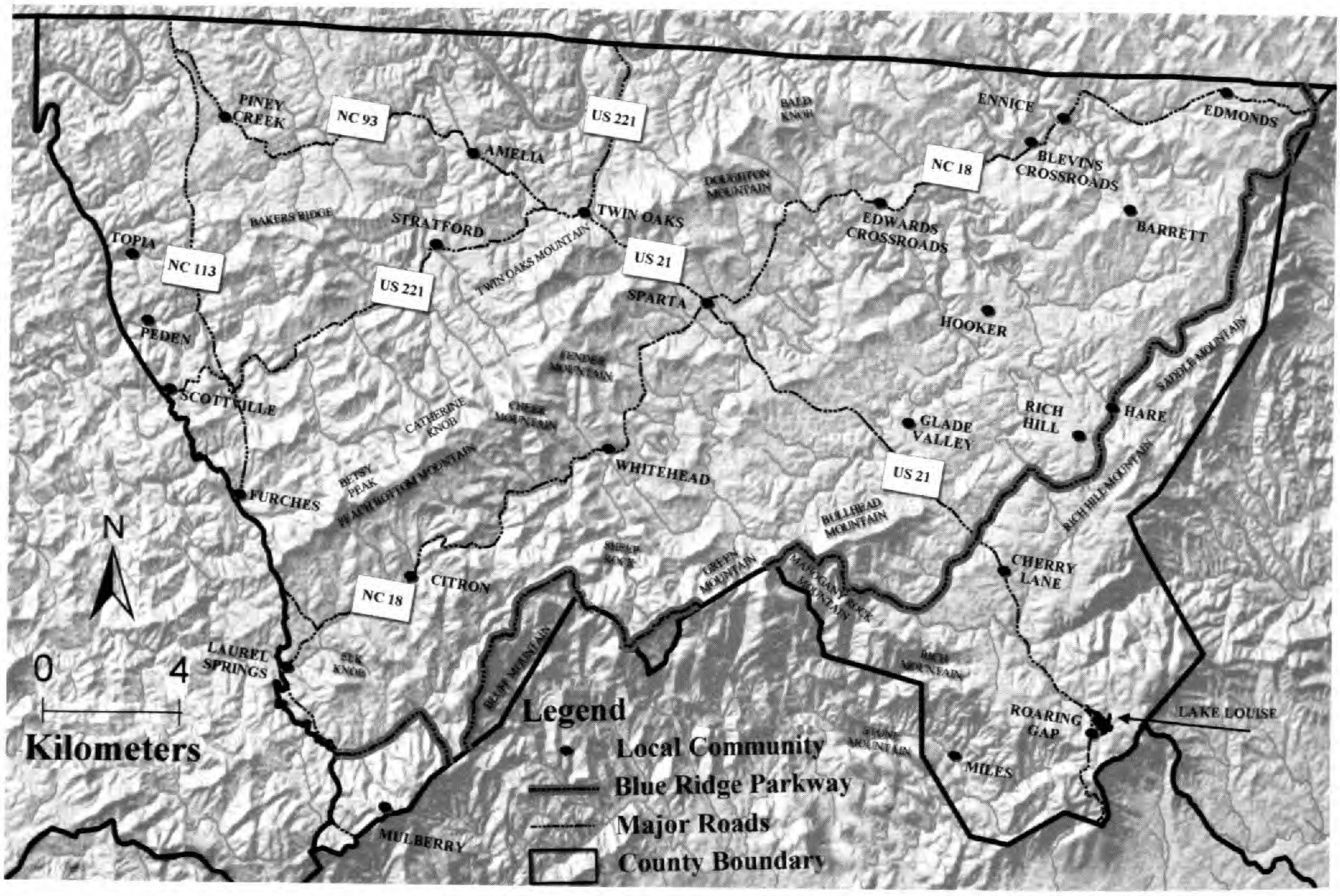


Fig. 2. Topography of Alleghany County, with emphasis on major roads, communities, reservoirs, and peaks.

tion consist of long horizontal bodies dominated by mica schist or phyllite (commonly graphitic) containing garnet and magnetite, interlayered with lesser amounts of biotite-muscovite gneiss and amphibolite. Another area dominated by amphibolite (some garnet based) and greenstone occupies a northeastern oriented sliver, equidistant between Cherry Lane and Roaring Gap (Rankin et al. 1972; Epenshade et al. 1975; USGS 2011).

The Ashe Formation occupies a third to nearly half of the county adjacent to and west of the Alligator Back Formation. It also runs horizontally in a northeast trajectory through the center of Alleghany. This formation encompasses the Peach Bottom Mountain range, Doughton Mountain, the county seat of Sparta, and Stratford. This late Precambrian (late Proterozoic) formation is dominated by rocks that are thinly layered and fine-grained. As mapped by Rankin et al. (1972), Epenshade et al. (1975), and USGS (2011) primary bedrock material is comprised of biotite-muscovite gneiss, with varying amounts of mica schist, phyllite, quartz, feldspar, amphibolite, and hornblende gneiss. Gneiss layers are most common and often very thick. Several long, narrow bands dominated by amphibolite and garnet amphibolite are scattered throughout the formation. These mafic bedrocks are found in areas from Sparta to Ennice, south of Sparta, from Furches northeast to Stratford, near Peden in the same trajectory through Amelia to the Virginia, and as another sliver from the northwest section of the South Fork of the New River, south of Piney Creek and bisecting the northern "loop" of the New River along the northern border of the county (Rankin et al. 1972; Epenshade et al. 1975; USGS 2011).

The Elk Park Plutonic Group or Suite is the second smallest lithologic assemblage in Alleghany County, found in the northwest corner, surrounding Piney Creek and the confluence of the North and South Forks of the New River, along with one section of the New River itself. It is comprised of intermediate Precambrian (mid-Proterozoic), metamorphic and igneous rocks. The largest, most common body of rocks is referable to Cranberry Gneiss (biotite granitic gneiss), containing rocks that range from diorite to granite, with quartz monzonite that often bears biotite. Some hornblende (amphibolite), calc-silicate rock, and marble is present, and sphene and epidote are common (Rankin et al. 1972; Epenshade et al. 1975; USGS 2011)

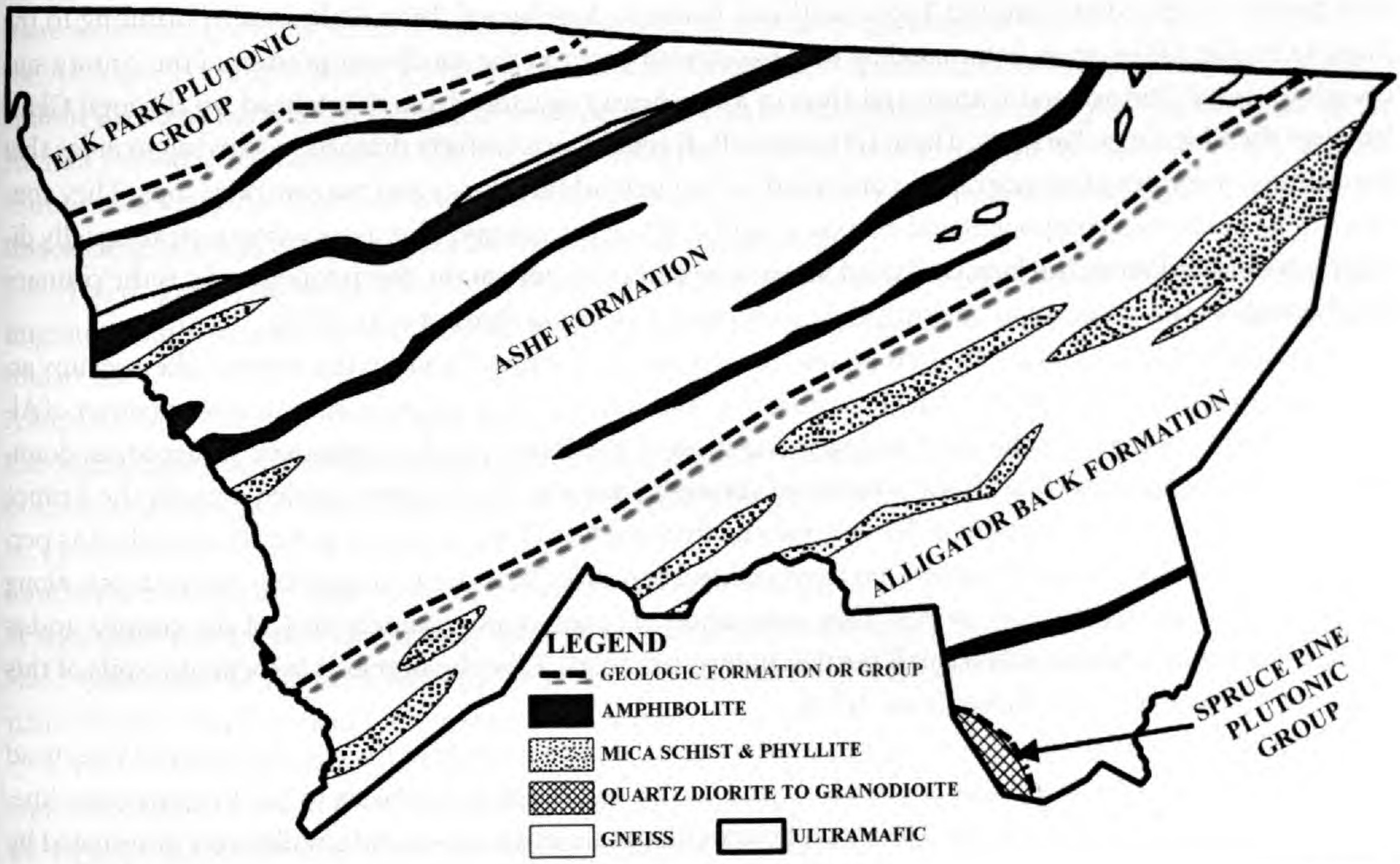


Fig. 3. Generalized geologic map of Alleghany County, adapted from Padgett (2011) and based upon Epenshade et al. (1975) and Rankin et al. (1972).

The Spruce Pine Plutonic Group is restricted to a very small area around Stone Mountain State Park along the western side of the southeast leg of the county. This group of intrusive igneous rocks consists primarily of Paleozoic (Devonian) granitic substrates including quartz diorite, granodiorite, biotite, muscovite, and quartz monzonite, with frequent epidote and local garnet (Rankin et al. 1972; Epenshade et al. 1975; USGS 2011).

The ultramafic metamorphic rocks of this area occur in small bands or pockets within the Ashe Formation. Of these areas, Amelia, Edmonds, and Peden contain the largest consolidated localities for this rare substrate. Likewise, the Edmonds portion extends northeastward into Virginia, constituting one of the largest bodies of ultramafic rock in the southern Appalachians. These ultramafic rocks are of an undetermined Precambrian and/or Paleozoic origin and are exceedingly rich in minerals. Areas containing this rock type consist principally of chlorite-tremolite-magnetite schist with common deposits of either serpentine or talc, and local occurrences of olivine (Rankin et al. 1972; Epenshade et al. 1975; Scotford & Williams 1983). Such bedrock releases abundant minerals upon weathering, and thus often produces habitats that harbor rare plants. Elements (particularly heavy metals) commonly found in ultramafic rock are magnesium, iron, aluminum, calcium, nickel, cobalt, manganese, zinc, copper, and potassium. Those of Alleghany County belong to two types, the Edmonds-type and the Todd-type. Both types are metasomatized, with the Edmonds-type rocks being less altered and found in the eastern half of the county, and the Todd-type in the western half (Scotford & Williams 1983).

Soils

The soils of the county are primarily classified as Ultisols, with a few examples of Inceptisols, and one series with Entisols. Most soils in the county are derived from gneiss and schist, with occasional phyllite and rarely granite. The soil texture is mainly loam to a fine sandy loam, containing varying amounts of mica. The soils of Alleghany County are more specifically partitioned into five main units: the Watauga-Chandler-Fannin association, Chester-Ashe association, Porters association, Clifton association, and Stony steep land association (Brewer et al. 1973).

The Watauga-Chandler-Fannin association is widely distributed, occurring in large areas in the north-

west portion of the county around Topia northeast between Amelia and Twin Oaks, and continuing to the Virginia border. Other areas dominated by this association occur in the southwest portion of the county surrounding Laurel Springs and Citron, and then in a northeast trajectory from Whitehead up through Glade Valley to the Blue Ridge Parkway. These soils are well-drained to excessively drained, occurring in areas that are rolling to very steep in topography, particularly along upland side slopes and narrow ridge tops. They contain a large micaceous component and occupy roughly 39% of the county. This association is near equally divided into forested areas and farmland used for pasture and crop cultivation. Steep topography is the primary disadvantage of this association, making these soils prone to erosion (Brewer et al. 1973).

The Chester-Ashe association is the second most prominent series of soils in the county. They occupy areas primarily in the eastern half of Alleghany County, but with one large region in the northwest corner of Alleghany County west of Amelia and encompassing most of the Piney Creek community. Other areas dominated by this association occur from Whitehead through Sparta to the Virginia border, around the Ennice community, and south surrounding Cherry Lane and Roaring Gap. These soils are generally classified as permeable to excessively permeable, and often have surficial bedrock. They occur on gentle to steep slopes, along broad ridgetops and upland side slopes. This association occupies approximately 36% of the county, and is mostly used for cultivation (only a small portion in forested areas). Like the previous association, soils of this group are subject to erosion (Brewer et al. 1973).

The Porters association includes soils primarily in west-central section of the county, west of Whitehead and south of Twin Oaks, beginning southwest from NC 113 and running northeast to the Virginia State line, encompassing Fender Mountain and the Peach Bottom Mountain range. A second smaller area dominated by this association occurs south of Glade Valley along the northern side of Bullhead Mountain. Soils of the Porters association tend to be well-drained and occur on strong to very steep side slopes and narrow ridges of the higher elevation areas in the county. This association occupies about 12% of the land in Alleghany County, much of which is forested. The rugged topography dominated by this association makes agriculture difficult in these areas, coupled with bedrock that is near the soil surface. Likewise, cultivation within this association is not practical due to a high probability of erosion (Brewer et al. 1973).

The Clifton association is comprised of soils mainly in the north and northwestern portions of the county. They occur in small bands, specifically around Peden northeast to Stratford, more or less parallel to US 221 and terminating just south of NC 93. This band continues along this trajectory on the north side of NC 93 until reaching the Virginia border. The only other area where this association is found is around the Edwards Crossroads community and northeastward. Soils of this series are relatively well-drained. The Clifton association is found in rolling to somewhat steep sites, along rather broad ridgelines and upland slopes. These soils are the least common in the county, occupying about 6% of the land area with half in forest and half in cultivation. Like the previous associations, these soils have a limited farming capacity due to steep topography and surficial bedrock (Brewer et al. 1973).

The Stony steep land association is found mainly along the rim of the Blue Ridge Escarpment, in the extreme southern, southeastern, and northeastern portions of the county. These areas are adjacent to Wilkes and Surry Counties. Soils of this association are very rocky with exposed bedrock, and generally occur on very narrow ridgetops and steep side slopes, with especially narrow drainage ways. Most of this land belongs to the Blue Ridge Parkway, and is thus relatively undisturbed. Likewise, the steep topography and unsuitable soils make it non-conducive for agriculture. Approximately 7% of the county is occupied by this association, with roughly 90% of it consisting of forested areas (Brewer et al. 1973).

History and Special Features

The first known inhabitants of Alleghany County were Native Americans. Relictual evidence and other artifacts suggests that these cultures were present near the beginning of the Hypsithermal period, at the end of last Pleistocene Glaciation, approximately 10,000 years ago (Alleghany Historical-Genealogical Society [AHGS] 1983). Three major divisions are recognized based on the progressively more advanced implements found in the county, that ultimately resulted in a transition from a nomadic (seasonal hunting migration) lifestyle to

more sedentary (farming infused) society. These time frames correspond to the Paleo Period (ca. 10,000 B.C.), the Archaic Period (8,000 B.C.), and the Woodland Period (ca. 0–1,700 A.D.). Interestingly, there was also a shift in the areas normally inhabited by early peoples, with a transition from ridge top and uplands during the Archaic Period to lowland areas (likely more conducive to agriculture) during the Woodland Period. The first European settlers that migrated into what is now known as Alleghany County found few native Americans, but this small group was comprised of Cherokee Indians (AHGS 1983).

The original Europeans (mostly of English, German, Scottish, and Irish descent) to inhabit this county migrated south through the Shenandoah River Valley, as well as from other western portions of Virginia in the mid to late 1700s. This county was initially part of a larger Ashe County before its separation from northeastern Ashe and subsequent establishment as a new political entity by an act of the 1858–1859 session of the North Carolina Legislature (Brewer et al. 1973; Alleghany County Historical Committee [ACHC] 1976). The location of the county seat of Sparta was heavily debated for several years during the Civil War, and was not formally recognized in its central locality until 1866, following the donation of 20.2 ha of land by James Parks, David Landreth, and David Evans. County residents initially wanted to name this home for county government "Parks" after the primary land donor, but instead he insisted on naming it "Sparta" after the ancient Greek city-state. Likewise, the name "Alleghany" is purported to be derived from an alteration of the Delaware Indian name for the Allegheny and Ohio rivers, and allegedly translates as "a fine stream" (ACHC 1976; AHGS 1983).

Two of the most important features of human interest in Alleghany County include the Federally owned and maintained Blue Ridge Parkway (BRP), and the nationally significant New River. The BRP serves as a scenic byway diagonally traversing part of the southern Appalachian Mountains. The lands preserved by the parkway are of substantial importance due to the habitats they preserve. The first section of the BRP was built at Cumberland Knob in Alleghany County between 1935 and 1939 (Penny 2010). Over the past couple of years, the historic rock walls serving as roadside barriers and complimenting the natural aesthetics of this roadway have been restored. Similarly, the New River is a natural physical element of the county of great interest. The New River is part of the Ohio River watershed and is a tributary of the Kanawha River. It is believed by many to be one of the oldest rivers in the world, with its origin predating the Appalachian Mountains. Due to its unique nature, it is considered one of the nation's American Heritage Rivers. This river not only provides a source of recreation and beauty in the county, but also is rather pristine and serves as a sanctuary to many rare plants and animals.

Land Use

Alleghany County is primarily a rural area with an economy driven by agriculture. According to the 2007 agricultural census (North Carolina Department of Agriculture and Consumer Services [NCDACS] 2012a), approximately 310.2 km2 (51.0% of the total land area) of this county is used for farmland. Some of the major agricultural products for this county include Christmas trees (2nd leading producer in the state), burley tobacco (5th in the state), corn for silage (3rd in the state), and milk cows (4th in the state) (NCDACS 2012a, 2012b). Boxwoods (*Buxus* spp.) are also planted in large quantity in the county, although this horticultural crop is apparently not a major commodity and thus is not monitored by the North Carolina Department of Agriculture (pers. obs.). This high level of agriculture-driven land use has led to a very fragmented and highly altered landscape in the county.

Like many rural counties, Alleghany contains many small, local communities. Many of these communities have greatly dissipated over time and are hardly recognized currently, however the historical and current presence of these areas of human aggregation are important as they define centers of concentrated anthropogenic influence. Many of the larger extant communities (including the county seat of Sparta) are located along or near major roadways and include Cherry Lane, Edmonds, Ennice, Glade Valley, Piney Creek, Roaring Gap, Stratford, Twin Oaks, and Whitehead (Fig. 2).

In 1880, nearly 20 years after its formal establishment, Alleghany County had a population of 5,486 people (Brewer et al. 1973). Based on the 2010 U.S. Census Bureau data (USCB 2012), Alleghany has an estimated population size of 11,155 people, making it the 7th smallest in the state.

Major Collectors and Floristic Studies

The first plant collections known to the author from Alleghany County, based on herbarium specimens, were in the early 1900s. Fieldwork in the county (as well as North Carolina in general) peaked during the 1950s and 1960s during the production of the *Manual of the Vascular Flora of the Carolinas* (Radford et al. 1968). Two M.S. theses were conducted in Alleghany County, either as a site within the confines of the County's political boundaries (Bullhead Mountain, Michael 1969) or as a site that overlapped the boundary with a neighboring county (Stone Mountain State Park, Taggart 1973, 1976). In the last decade, there have been only a few other published works pertaining to newly documented plants in Alleghany County (Poindexter 2006, 2008; Denslow & Poindexter 2009; Poindexter 2010a, 2010b; Poindexter & Lance 2011; Poindexter & Nelson 2011; Poindexter et al. 2011). Botanists and avid collectors that have made significant contributions to the knowledge of floristic diversity in this county within the last 50 years include A.E. Radford, J.B. Taggart, J.L. Mackay, J.L. Michael, and county natives P.D. McMillan and myself.

METHODS

Specimens were collected from the spring of 2008 through the summer of 2012. Despite the presence of preexisting vouchers, an attempt was made to recollect all known taxa to produce the most up-to-date records possible. This documentation effort was augmented by herbarium searches for additional vouchers. The full collection at Appalachian State University (BOON) was examined, while other herbaria were targeted for specific records based on database and/or literature searches. These herbaria included: Catawba College, Clemson University (CLEMS), Duke University (DUKE), Mecklenburg County Park and Recreation (UNCC), North Carolina State Museum of Natural Sciences, University of Missouri (UMO), North Carolina State University (NCSC), University of North Carolina-Chapel Hill (NCU), University of South Carolina-Columbia (USCH), and Virginia Tech (VPI). All specimens were examined for accuracy and annotated.

Weakley (2011) was the primary source for plant identification and nomenclature (exceptions are addressed separately). Other manuals consulted include: Bailey (1924), Bailey and Bailey (1976), FNA (1993+), Fernald (1950), Gleason and Cronquist (1991), Radford et al. (1968), Rehder (1937), Small (1933), Stace (2010), and Wofford (1989). Decisions regarding alien species inclusion followed a liberal philosophy (see Poindexter et al. 2011; Weakley 2011), whereby all exotic plants that are either naturalized or demonstrate the ability to migrate from an origin of cultivation or inadvertent seeding (e.g., adventives/waifs, escapes) are considered part of the flora. This inclusive approach acknowledges that establishment is not easily determined, and the most pragmatic solution is to recognize all unmanaged taxa for monitoring purposes. In addition to this approach, taxa that are derived from cultivation but are commonly persistent (particularly around old homesites) or planted with such regularity that they are perpetual agroeconomic elements of the county flora (e.g., *Abies fraseri*) were also documented. In general, all other cultivated taxa that were demonstrably maintained through human interaction and not spreading were not vouchered.

The following terminology was applied to taxa not indigenous to the eastern United Stated and native cultivated species as adapted from Poindexter and Murrell (2008): *exotic* = any nonnative taxon considered naturalized unless otherwise noted; *invasive* = naturalized exotics capable of becoming dominant in an area and regularly invade natural and disturbed habitats; *adventive* = unintentional and sporadic introductions of generally short-lived (i.e., annual) exotic taxa; *native persistent from cultivation* = intentionally planted persistent species that are native to the eastern United States, but not necessarily to the study area; *exotic persistent from cultivation* = planted and established (i.e., surviving for several years) but not spreading; and *escaped* = generally perennial taxa (including both exotic and planted natives) that appear to weakly spread from cultivation and may possibly become established. Taxa were determined to be invasive in the southeast based on the Southeast Exotic Plant Pest Council ([SE-EPPC] 2012). This list was followed closely, except in a few rare cases where nativity is questionable (e.g., *Solanum carolinense* var. *carolinense*).

Putative assignments for county and state records were determined based on Radford et al. (1968), Flora of the Southeast atlas (FSE 2012), FNA (1993+), Kartesz (2012), and the PLANTS Database (United States De-

partment of Agriculture, Natural Resources Conservation Service [USDA, NRCS] 2012). State records originating from Alleghany County in other recently published literature (e.g., Poindexter et al. 2011; Rothrock et al. 2011) were also noted. State and global rarity was accessed for each taxon based on the North Carolina Natural Heritage Program (Buchanan & Finnegan 2010). "Significantly Rare" and "Watch List" species were reported to the North Carolina Natural Heritage Program to promote conservation efforts. Taxa that were simply persistent from cultivation were not considered as county or state records. Likewise, persistent or weakly escaped cultivated natives were not assessed for rarity.

The full set of voucher specimens from this study was deposited in the Appalachian State University Herbarium (BOON), with a limited set at the UNC-Chapel Hill Herbarium (NCU), and a partial duplicate set of *Carex* at the New York Botanical Garden (NY). Additional select duplicates were sent to various institutions and may be located in the customized online database described below.

All specimens were georeferenced with a handheld Garmin™ GPSMAP 60Cx unit as they were collected, using WGS 84 as the reference datum. Legacy specimens from other herbaria that lacked GPS coordinates were assigned an estimated coordinate using Google Earth ™ and an existing knowledge of the geographical and ecological attributes of the county. This heuristic method was employed, rather than utilizing less precise georeferencing software, to increase location accuracy. The flora was digitized and used to create an online searchable database of specimens and their respective repositories, select field images, and associated label data. Certain specimen locality data (but not images) were blocked due to land ownership or conservation concerns. This tool was generated as a companion outlet for the extensive amount of floristic information that does not traditionally occur in manuscripts. It was also created to help the general public, land managers, educators, and researchers better understand the flora, and possibly add to our knowledge of the county's vascular plant diversity (via new additions and annotations/corrections) in the future. This website can be accessed at www.vascularflora.appstate.edu (Poindexter 2012). Search filters are also provided in this database for specimens associated with the Blue Ridge Parkway, as well as for vouchers corresponding to an ancillary biocontrol study focusing on the vegetation dynamics and management of *Persicaria perfoliata* within the county. A downloadable copy of the annotated list (vouchered taxa only) in Microsoft Excel ® format is also provided on the website to allow for data parsing and integration by researchers.

Species richness was evaluated for the Alleghany County flora using multiple power models. A conservative approach was taken, utilizing species numbers (rather than total taxa) to safely compare at the same level of taxonomic resolution. These models are represented as $S = cA^z$, where S = the number of expected species for a given area (A), c = the y-intercept or constant, and z = the slope or z coefficient. Area (A) units are in number of hectares. This model is also accompanied by a coefficient of determination (r^2), which ranges from 0 to 1 and describes how well a regression line fits the data. Values closer to 1 indicate a better fit. Three unpublished models, based on data from the FloraS of North America Project (the "S" symbolically distinguishes this project from the similar-sounding "Flora" of North America Project; http://botany.okstate.edu/floras/index.html), were supplied by M.W. Denslow (Appalachian State University, two North Carolina models) and M.W. Palmer (Oklahoma State University, one continental United States model). The first model was broadly inclusive for the North Carolina Mainland (including all physiographic provinces and excluding barrier islands; $S = 130.30A^{0.154}$, $r^2 = 0.443$), and the second model was based exclusively on floras from the mountains of North Carolina ($S = 76.10A^{0.210}$, $r^2 = 0.537$). The latter broad-scale model for the continental United States was based on 3600 floras ($S = 106.44A^{0.16042}$, $r^2 = 0.557$). In addition, published models from the Cumberland Plateau (Huskins & Shaw 2010; $S = 82.12A^{0.2613}$, $r^2 = 0.780$) and two models from the Mixed and Western Mesophytic forest region (Wade and Thompson 1991 [$S = 272.10A^{0.113}$, $r^2 = 0.802$]; Huskins and Shaw 2010, corrected model [$S = 260.82A^{0.1164}$, $r^2 = 0.769$]) were assessed.

Plant communities were delineated through field reconnaissance and collections, as well as the evaluation of several physical parameters, including general topography, aspect, moisture regimes, soil and geology, dominant species, anthropogenic influence, and general vegetation composition. This study relies heavily on these personal observations in conjunction with the North Carolina Natural Heritage Program Significant

Natural Heritage Inventory (Padgett 2011). Likewise, habitat affinities were derived for each taxon (where applicable) by using the PLANTS Database (USDA, NRCS 2012) to assign wetland indicator status (based on the 1988 list). This method was employed to qualitatively ascertain additional ecological patterns within the flora. Modern techniques and current flora writing standards (e.g., Palmer et al. 1995; Palmer & Richardson 2011) were followed as closely as possible to maximize the utility and accessibility of data within this study.

RESULTS AND DISCUSSION

Taxonomic Summary

Approximately 3754 specimens (including duplicates) were collected by the author. An additional series of ca. 285 specimens were examined from various collectors and institutions (see Methods). A total of 1508 taxa, consisting of 1457 species in 642 genera and 161 families were documented, with only 36 taxon records (mostly historical) attributed to other collectors. These taxa are represented by nine Lycopodiophyta, 39 Monilophyta, 23 Acrogymnospermae, and 1437 Angiospermae (Table 1). The latter clade can be further divided into 412 Monocotyledoneae (Monocots) and 1025 "Dicots" in the traditional sense. This latter informal grouping is non-monophyletic, and to better reflect our current understanding of phylogenetics, it is best subdivided into proper clades. As such, there are two Nymphaeales, 13 Magnoliidae, and 1010 Eudicotyledoneae. The largest families are the Asteraceae (177 taxa), Poaceae (153 taxa), Cyperaceae (120 taxa), Rosaceae (74 taxa), Fabaceae (61 taxa), and Lamiaceae (54 taxa). The most taxa-rich genera are *Carex* (83), *Viola* (24), *Dichanthelium* (19), *Solidago* (16), *Juncus* (14) and *Symphyotrichum* (13). Four hundred and thirty-five taxa, constituting 28.8% of the total flora, are nonnative in the eastern United States, of which 141 (9.4% of total flora) are considered invasive in the southeastern United States (SE-EPPC 2012). This high exotic percentage is most likely the consequence of high levels of disturbance associated with large-scale agricultural practices and residential development.

To best discriminate the various origins of taxa reported in this flora, a quantitative summary of source categories is provided (Table 2). As interpreted, 1408 taxa (1360 species) are naturally/sporadically occurring exotic (including adventive) and native plants. The remaining 100 taxa (97 species) are derived from some cultivated origin. Excluding adventives, the full flora consists of 1382 taxa (1335 species).

A total of 38 additional records are tentatively included in the list (for a total of 1546 taxa, 1495 species) as they have been previously reported by reliable sources, but due to the lack of unequivocal physical evidence in the form of voucher specimens or images, these taxa are not part of the formal taxonomic summary. Likewise many other records have been excluded altogether due to either incorrect determinations or in case of sight records, were highly implausible to occur in the county based on geographical affinities. Twenty-nine records are from the FSE atlas (2012) database, which combines several data sources including Radford et al. (1968), The Carolina Vegetation Survey (http://cvs.bio.unc.edu/), and others. Nine taxa are based on records from the North Carolina Natural Heritage Program (NCNHP 2012). These collective sight records are uniquely denoted within the annotated checklist to avoid confusion.

Rare Taxa, State and County Records, and Other Taxonomic Issues

Sixty-five taxa (Table 3) are currently considered "Significantly Rare" by the North Carolina Natural Heritage Program (Buchanan & Finnegan 2010). Though several species from this county are listed as Federal Species of Concern, no Federally Endangered or Threatened taxa have been documented. An additional category monitored by the North Carolina Heritage Program contains "Watch List" species. This category accommodates taxa that are rare or threatened and demonstrate serious population decline, but are not justifiably worthy of major conservation efforts. Criteria for inclusion in this group range considerably. For instance, some taxa are included because they are rare but secure, regionally rare, rare and poorly known, rare due to severe decline, or simply increasing in rarity as a consequence of commercial exploitation. The flora of Alleghany County currently contains 100 taxa on this list.

Twenty-one state records have been previously published from plants in Alleghany County (Poindexter 2008, 2010a, 2010b; Poindexter & Lance 2011; Poindexter & Nelson 2011; Poindexter et al. 2011). An additional

TABLE 1. Classification of vouchered vascular plants of Alleghany County, North Carolina.

Major Clade	Families	Genera	Taxa	Native	Exotic	Percent of Total Flora
Lycopodiophyta	**3**	**6**	**9**	**9**	**0**	**0.60**
Monilophyta	**15**	**23**	**39**	**39**	**0**	**2.59**
Acrogymnospermae	**3**	**12**	**23**	**12**	**11**	**1.52**
Angiospermae	**140**	**601**	**1437**	**1013**	**424**	**95.29**
Monocotyledoneae	31	143	412	320	92	27.32
Nymphaeales	1	2	2	2	0	0.13
Magnoliidae	4	9	13	12	1	0.86
Eudicotyledoneae	104	446	1010	679	331	67.98
Totals:	**161**	**642**	**1508**	**1073**	**435**	**100.00**

TABLE 2. Comparative assessment of the origin of plants comprising the vascular flora of Alleghany County, North Carolina.

Origin	Number of Taxa	Number of Species	Percent of Flora*
Subcategories			
* = Naturalized Exotic	193	188	12.8 [0.1]
** = Invasive Exotic	138	135	9.2 [0.1]
‡ = Adventive Exotic	26	25	1.7 [0]
† = Exotic Persistent From Cultivation	39	39	2.6 [0.1]
∞ =Exotic Escaped From Cultivation	36	36	2.4 [0.1]
□ =Invasive Escaped From Cultivation	3	2	0.2 [-0.1]
Δ = Native Persistent From Cultivation	10	8	0.7 [-0.1]
^ =Native Escaped From Cultivation	12	12	0.8 [0]
All Plants of Cultivated Origin	100	97	6.6 [0]
Primary Categories			
Exotic	435	425	28.8 [0.3]
Invasive (naturalized and escaped)	141	137	9.4 [0.1]
Exotic (non-cultivated)	357	348	23.7 [0.2]
Exotic (non-cultivated and non-adventive)	331	323	21.9 [0.2]
Native	1073	1032	71.2 [-0.3]
Native (non-cultivated)	1051	1012	69.7 [-0.2]
Exotic + Native (non-cultivated)	1408	1360	93.4 [0]
Exotic + Native (non-cultivated and non-adventive)	1382	1335	91.6 [0]
TOTAL	**1508**	**1457**	

*Note: Percent of flora is based on total taxa at the species-level or below, with deviation from this value based on species only in brackets.

ten new records are included here for a total of 31 taxa recently documented as new to North Carolina from this area. These taxa include *Campanula punctata, Carex aestivaliformis, Crocus vernus, C. tommasianus, Euphorbia dulcis, Nymphoides peltata, Ribes hirtellum, Saponaria ocymoides, Stellaria longifolia,* and *Viburnum dilatatum*. Most of these records represent weakly spreading taxa from cultivation and a few native taxa. Six hundred and thirteen taxa (40.6% of the total flora) are new additions to the known vascular plant diversity of Alleghany County. Of these, 266 taxa are exotic (43.4% of the total county records) and 347 are native (56.6%).

Stachys appalachiana was recently described from neighboring Ashe County (Poindexter & Nelson 2011), and Alleghany is the only county in North Carolina (and one of only two globally) that has a confirmed extant population of this species. Likewise, a rare hybrid orchid, *Liparis ×jonesii* (*L. liliifolia* × *L. loeselii*), was originally described from this county (Bentley 2000), as was *Monotropsis lehmaniae* Burnham (Burnham 1906), which is currently considered a synonym of *M. odorata*. Several putative new taxa (though not necessarily endemic to Alleghany County) within various genera including *Carex*, *Erigeron*, and *Symphyotrichum* are being investigated.

TABLE 3. Rare vascular plants of Alleghany County as determined by the North Carolina Natural Heritage Program (Buchanan & Finnegan 2010), including protection status and rarity ranking. **Bold** taxa are unverified sight records not included in the taxonomic summary.

Taxon	State Rank	Global Rank	State Status	Federal Status
Adlumia fungosa	S2	G4	SR-P	
Arethusa bulbosa	**S1**	**G4**	**E**	
Arisaema triphyllum ssp. *stewardsonii*	S2	G5T4	SR-P	
Calamagrostis canadensis var. *canadensis*	S1	G5T5	SR-P	
Caltha palustris	**S1**	**G5**	**SR-P**	
Camassia scilloides	S1	G4G5	T	
Campanula aparinoides	S2	G5	SR-P	
Cardamine rotundifolia	S2	G4	SR-P	
Carex baileyi	S2	G4	SR-P	
Carex buxbaumii	S2	G5	SR-P	
Carex conoidea	S1	G5	T	
Carex sp. 2	S1	G1	SR-T	FSC
Carex oligocarpa	S1	G4	SR-P	
Carex trichocarpa	S1	G4	SR-P	
Carex utriculata	S1	G5	SR-P	
Carex vesicaria	S1	G5	SR-P	
Carex woodii	S3	G4	SR-P	
Caulophyllum giganteum	S1	G4G5Q	SR-P	
Chamerion platyphyllum	S1	G5T5	SR-P	
Chelone cuthbertii	S3?	G3	SR-L	FSC
Chelone obliqua	S2	G4	SR-T	
Chenopodium simplex	S1	G5	SR-P	
Cladium mariscoides	S3	G5	SR-O	
Coptis trifolia var. *groenlandica*	S1	G5T5	SR-P	
Crataegus coccinea	S2?	G5	SR-P	
Crocanthemum propinquum	S1	G4	SR-P	
Cuscuta cephalanthi	S1	G5	SR-T	
Delphinium exaltatum	S2	G3	E-SC	FSC
Dendrolycopodium hickeyi	S2?	G5	SR-P	
Deschampsia cespitosa ssp. *glauca*	S1	G5T5	SR-P	
Dichanthelium annulum	S1	GNR	SR-P	
Dichanthelium boreale	S2	G5	SR-P	
Dichanthelium spretum	**S1S2**	**G5**	**SR-D**	
Echinacea purpurea	S1	G4	SR-P	
Glyceria laxa	S1	G5	SR-P	
Hackelia virginiana	S1S2	G5	SR-P	
Helenium brevifolium	S2	G4	E	
Heuchera hispida	S1	G5T3?	SR-P	
Hexalectris spicata	S2	G5	SR-P	
Hydrastis canadensis	S2	G4	E-SC	
Lilium canadense ssp. *editorum*	S1	G5T4	SR-P	
Lilium grayi	S3	G3	T-SC	FSC
Liparis loeselii	S1	G5	SR-P	
Lonicera canadensis	S2	G5	SR-P	
Meehania cordata	S2	G5	SR-P	
Menyanthes trifoliata	S1	G5	T	
Micranthes caroliniana	S3	G3	SR-T	FSC
Monotropsis odorata	S3	G3	SR-T	FSC
Parnassia grandifolia	S2	G3	T	FSC
Platanthera grandiflora	**S2**	**G5**	**SR-P**	
Prenanthes alba	S2?	G5	SR-P	
Pycnanthemum virginianum	S1?	G5	SR-P	
Quercus ilicifolia	S2	G5	T	
Rhynchospora alba	S2	G5	SR-P	
Robinia hispida var. *fertilis*	S1	G4T1Q	SR-O	
Rubus dalibarda	S2	G5	E	
Sceptridium oneidense	S2	G4Q	SR-P	
Scutellaria saxatilis	S1	G3	SR-T	
Silphium connatum	S2	G3G4Q	SR-T	

TABLE 3. continued.

Taxon	State Rank	Global Rank	State Status	Federal Status
Silphium perfoliatum	S1	G5	SR-P	
Spartina pectinata	S1	G5	SR-P	
Spiraea corymbosa	**S1**	**G5T4?**	**SR-O**	
Spiranthes lucida	S1	G5	SR-O	
Stenanthium gramineum var. *robustum*	S1	G3G5Q	SR-P	
Thalictrum macrostylum	S2	G3G4	SR-L	FSC
Thelypteris simulata	S1	G4G5	T	
Vaccinium macrocarpon	S2	G4	SR-P	
Veronica americana	S2	G5	SR-P	
Woodsia appalachiana	S2	G4	SR-P	
Woodsia ilvensis	S1	G5	SR-P	

S1 (GI) = critically imperiled in state (globally), 1-5 extant populations; S2 (G2) = imperiled in state (globally), 6-20 extant populations; S3 (G3) = rare or uncommon in state (rare throughout range or occurring in a restricted habitat), 21-100 extant populations; G4 = apparently secure globally, 100-1000 extant populations; G5 = demonstrably secure globally, 1000+ extant populations; G_Q = questionable taxonomic assignment; T_ = rank of subspecies or variety

E = Endangered, continued existence in state in jeopardy; T = threatened, likely to become Endangered through all or a portion of range; SR = Significantly Rare, 1-100 populations statewide and reduced by habitat destruction; SR-L = endemic or near-endemic to NC; SR-T = rare throughout global range; SR-D = disjunct to NC from a main range elsewhere; SR-P = occurs at periphery of range; SR-O = range is sporadic or cannot be accommodated under other Significantly Rare categories.

FSC = Federal Species of Concern. (explanation of ranks from Sorrie et al. [2006]).

As with any large scale study, many taxonomic issues were encountered. Some of these, for example, involve:

1. *Acer*—collections referred to as *Acer nigrum* are atypical for this species and may represent additional variation within the *A. saccharum* species complex.
2. *Calystegia*—members of the "*sepium* complex", as well as *C. silvatica* ssp. *fraterniflora*, are highly variable and often difficult to segregate.
3. *Elymus*—some individuals appear intermediate between *E. glabriflorus* and *E. macgregorii*, while *E. virginicus* is presumably absent from the flora.
4. *Eutrochium*—high levels of morphological variation in trichome structure for *E. purpureum* var. *purpureum* are not well addressed in the literature.
5. *Fallopia*—many populations are intermediate between *F. cristata* and *F. scandens* with regard to fruit morphology.
6. *Lycopus*—potential introgression between most *L. uniflorus* and *L. virginicus* (see Henderson 1962) in Alleghany County has produced a swarm of entities attributable to the hybrid *L. ×sherardii*. Gene flow between these two species seems plausible, and few if any populations of either species appear "pure."
7. *Pycnanthemum*—at least two distinctive and consistently separable entities are combined within the concept of *P. muticum*. Likewise, many aberrant forms not assignable to any concept were encountered.
8. *Tilia*—several populations, particularly in mafic sites, have abaxial leaf vestiture approaching var. *americana* and clearly not densely stellate-tomentose as in the frequently encountered var. *heterophylla*; however, these aff. var. *americana* populations do possess sparse stellate trichomes intermixed with acicular hairs suggesting some local introgression between these taxa.
9. *Vitis*—like many other taxa with intergrading varieties (e.g., *Fagus grandifolia*), *V. aestivalis* var. *aestivalis* and var. *bicolor* can only rarely be differentiated.

Species Richness

To date, only three floristic inventories that were explicitly considered comprehensive (i.e., collections made over one or more full growing seasons) for a given county within North Carolina have been conducted (Horton 1957; Britt 1960; Blair 1967). However, other inventories have been published that consist of areas of compa-

rable size to a county, but were not within equally defined political boundaries (e.g., Sorrie et al. 2006; 734.8 km^2 = 1206 taxa). Similarly, some floras have implied that they were county-wide in scope, but have either admitted to the inadequate collection of certain plant groups (e.g., Memminger 1915) or were fractious and ill-defined (Wood & McCarthy 1886; 1202 taxa; Peattie 1928, 1929a, 1929b, 1929c, 1930, 1931, 1937; 1090 taxa). All three of the presumably complete county floras were M.S. theses that were not formally published. These studies include Beaufort County (Blair 1967; 2142.4 km^2, 951 taxa), Robeson County (Britt 1960; 2458.5 km^2, 931 taxa), and Rowan County (Horton 1957; 1324.4 km^2,787 taxa). These floras represent areas within the Tidewater/Coastal Plain, Coastal Plain, and Piedmont regions of North Carolina, respectively. This checklist for Alleghany County constitutes the first full county flora primarily from the Mountain region of the state, as well as the first such flora to be produced in the last 45 years. It also important to note that Memminger's work was within an entirely montane county (Henderson County). On a similar note, Peattie's studies were chiefly within a Piedmont county with some mountains to the far west (Polk County and adjacent South Carolina). Likewise, Alleghany is a far smaller county, but contains more recorded taxa than previous county-wide comprehensive studies.

To assess the comprehensive nature of this study, several species area power models were consulted. Despite considerable variation between models (Table 4), all demonstrated a 40% or greater positive percent deviation from the number of predicted species for this flora, except for the Cumberland Plateau model, which indicated a slight negative deviation from the expected number of species. This divergence from the other models is likely attributed to the source data used to develop this regression curve. No floras in excess of 10,300 ha were utilized by Huskins and Shaw (2010), thus making an area the size of Alleghany County well outside the predictive limitations of the derived model. Based on this analysis, Alleghany County exhibits a species richness far above what would be expected for an area its size (Table 4). For example, when excluding cultivated taxa, the total species predicted for the North Carolina Mainland is 711. The actual number of species is nearly twice this prediction (1360 spp.) or 91.3% above the predicted number.

This high species richness is most likely the consequence of a broad array of community types and habitats (see below), and the county's small but notable ecotone-like transition from the Mountains to the Piedmont (foothills). The geologic, edaphic, hydrologic, and climatic heterogeneity of Alleghany County plays a major role in this pronounced species richness. Likewise, high levels of disturbance have added a prominent exotic component to the flora, which undoubtedly contributes to this higher than predicted richness. Similarly, the general paucity of large-scale (countywide or bigger) studies for model construction may also bias species area predictions. In contrast, some recent data also suggest that newer floras generally exhibit more species than older floras of comparable size areas (Denslow et al. 2010). A few additional variables that are likely responsible for these results include the application of narrower taxonomic concepts, a liberal criterion for alien species inclusion within the flora, time, effort, and prior floristic experience. Lastly, the fact that most models indicate that Alleghany County is far more species rich than expected suggests that this study is comprehensive.

Habitat Affinities

The landscape of this county is a mosaic of habitats, ranging from extremely dry to dry-mesic areas, particularly along the edge of the Blue Ridge Escarpment and adjacent foothills, to mesic coves and inundated bogs and wetlands. National Wetland Indicator Status 1988 list (USDA, NRCS 2012) provides a subjective measure of a plant's environmental preference via its hydrological amplitude. This status, though relative, adds to the ecological attributes of a flora. "Regional Status" for the Southeast (since some plants demonstrate different wetland preference in other geographical regions) was accessed for all taxa, with a separate analysis of taxa from non-cultivated origins (i.e., naturalized + invasive + adventive + native) included in brackets. Of the total flora, only 859 (57.0%) [835 59.3%] had a regional designation. These plants were divided near equally into three groups. The first group was comprised of "upland" and "facultative upland" taxa (287, 33.4%) [279, 33.4%], which are most likely to occur in non-wetlands. A second group consisted of "facultative" taxa (260, 30.3%) [253, 30.3%] that are equally likely to occur in non-wetlands or wetlands. The third group contained "facultative wetland" or "obligate wetland" taxa (312, 36.3%) [303, 36.3%], which were most likely to occur in

TABLE 4. Comparison of various species-area models utilizing the known vascular flora of Alleghany County, North Carolina.

	SPECIES-AREA MODELS				
Origin	NC Mainland	NC Mountains	Continental US	Cumberland Plateau	Mixed and Western Mesophytic Forests
	711 spp.	770 spp.	623 spp.	1462 spp.	945 spp.
Exotic + Native (non-cultivated) 1360 spp.	91.3	76.6	118.3	-7.0	43.9 [0.8]
Exotic + Native (non-cultivated and non-adventive) 1335 spp.	87.8	73.4	114.3	-8.7	41.3 [0.8]
All Species 1457 spp.	**104.9**	**89.2**	**133.9**	**-0.3**	**54.2 [0.8]**

Note: Species-area models compare at the species-level only and values represent percent deviation from the predicted number of species (predicted number listed under each model). A proposed corrected version (Huskins and Shaw 2010) of the Mixed and Western Mesophytic forest regions model (Wade and Thompson 1991) is provided in brackets as a percent deviation from the respective original model.The first two origin categories also exclude persistent species, while the last category is all inclusive and intended for comparison purposes only.

wetlands. These data confirm that Alleghany County has a wide range of habitat heterogeneity and thus help to explain the high level of floristic diversity found here.

Communities

The plant communities of Alleghany County are initially divided into two categories: natural and disturbed. As implied, natural communities are relatively unaltered areas containing native elements indicative of little anthropogenic influence. Natural communities are organized into affiliated groups and modified (including additions) from Padgett (2011), with subtypes and respective current ranks derived from the North Carolina Natural Heritage Program database (NCNHP 2012). Entries for each provisional community include subtypes listed in brackets with corresponding ranks, followed by a brief general description of the major community as it idiosyncratically occurs in Alleghany County. These categories follow the definitions of Schafale and Weakley (1990) and Schafale (2012). Community assessment was coarsely qualitative in nature and consequently, several other communities and/or subtypes are likely present and may be recognized in the future based on the updated and more finely divided classification scheme of Schafale (2012). Lastly, an additional informal community type (Montane River Aquatic) is qualitatively expanded from previous concepts for the purpose of this study. State Ranks (S) and Global Ranks (G) follow each community type in brackets. Exact definitions for these ranks are enumerated by Padgett (2011), but in general, lower ranks indicate greater conservation concern, ranging from 1 (critically imperiled) to 5 (demonstrably secure). Disturbed communities are generically defined.

NATURAL COMMUNITIES

High Mountain Communities

1) *High Elevation Red Oak Forest* [*Heath Subtype* S2S3 G4].—This community type is not very common as it typically occurs at elevations in excess of 1067 m. Forest structure is generally open and composed of a canopy dominated by *Quercus rubra* var. *rubra*, a near absent subcanopy, a patchy to moderate shrub layer, and a predominately thick orchard-like understory that exhibits less diversity than more mesic cove forests. Good examples of this community occur at Bullhead Mountain and nearby along the Blue Ridge Parkway around Mahogany Rock. In addition to *Quercus rubra* var. *rubra*, other rarely intercalated canopy species include *Betula lenta* var. *lenta*, *Carya glabra*, and even more rarely *Fraxinus americana*, *Quercus coccinea* and *Q. montana*. Understory species include *Acer pensylvanicum*, *Amelanchier arborea*, *Cornus florida*, and *Ilex montana*. Characteristic shrubs include *Kalmia latifolia*, *Rhododendron calendulaceum*, *Vaccinium corymbosum*, and *V. pallidum*. *Castanea dentata* sprouts are often present as well within the shrub layer. The rather dense herb layer is often composed of *Ageratina altissima* var. *roanensis*, *Aralia nudicaulis*, *Carex brunnescens var. sphaerostachya*, *C. debilis*, *C. laxiflora*, *C. virescens*, *Danthonia compressa*, *Dennstaedtia punctilobula*, *Eurybia chlorolepis*, *Maianthemum canadense*, *Solidago curtisii*, and *Thelypteris noveboracensis*.

Low Elevation Mesic Forest

2) *Acidic Cove Forest* [*Typic Subtype* S5 G5].—This community is rather common in the mountains of North Carolina. In Alleghany County it often occurs on midslopes at low to mid-elevations in narrow rocky gorges, usually with some substantial rock outcrops. It differs from Rich Cove Forest due to nutrient-poor edaphic conditions. This community regularly transitions into Rich Cove Forest along bottomlands where richer soils accumulate. It often grades into oak-hickory dominated forests upslope, in drier ridge-top areas. The canopy is primarily closed and often dominated by *Acer rubrum* var. *rubrum*, *Liriodendron tulipifera* var. *tulipifera*, *Quercus montana*, *Q. rubra* var. *rubra*, and *Tsuga canadensis*, with infrequent *Acer saccharum*, *Carya cordiformis*, and *Fraxinus americana* present. Subcanopy species are relatively few, with occasional *Cornus florida* and *Fagus grandifolia* var. *caroliniana* present. The shrub layer is dense, primarily comprised of evergreen ericaceous shrubs such as *Kalmia latifolia*, *Rhododendron catawbiense*, and *R. maximum*, with rare occurrences of *Leucothoe fontanesiana* and deciduous species such as *Rhododendron periclymenoides*. The herb layer is relatively thin, with small patches of dense vegetation restricted to canopy gaps. Characteristic species include *Asplenium platyneuron*, *Carex digitalis* var. *digitalis*, *C. nigromarginata*, *Chimaphila maculata*, *Galax urceolata*, *Maianthemum racemosum* ssp. *racemosum*, *Medeola virginiana*, *Polystichum acrostichoides*, *Ranunculus allegheniensis*, *Sanicula canadensis* var. *canadensis*, *Viola hastata*, and *V. hirsutula*.

3) *Rich Cove Forest* [*Montane Intermediate Subtype* S4 G4; *Montane Rich Subtype* S3 G3G4].—Rich Cove Forest is generally common and well distributed throughout the southern Appalachian mountains. It is most frequently associated with sheltered ravines along the Blue Ridge Escarpment, on upper slopes above the New River (and other tributaries), and on north-facing slopes and associated colluvial fans of major peaks within Alleghany County. These areas often include sheltered rock outcrops that are intermittent and too small to be characterized as cliffs. The occurrence of this community type is frequently correlated with geology, with most sites associated with mafic rock (amphibolite). The nutrient-rich conditions that characterize these forest types are also responsible for high levels of species diversity and vigorous vegetation growth. Consequently, the canopy layer of this forest type is generally closed, comprised of dense assortment of trees including, but not limited to *Aesculus flava*, *Betula lenta* var. *lenta*, *Juglans nigra*, *Liriodendron tulipifera* var. *tulipifera*, *Magnolia acuminata*, *M. fraseri*, *Prunus serotina* var. *serotina*, and *Tilia americana* var. *heterophylla*. Subcanopy trees often present are *Cornus alternifolia*, *C. florida*, *Fagus grandifolia* var. *grandifolia*, *Halesia tetraptera*, and *Hamamelis virginiana* var. *virginiana*. The shrub layer is often sparse, comprised of *Corylus americana*, *Hydrangea arborescens* var. *arborescens*, *Lindera benzoin*, and occasional *Pyrularia pubera*. The herb layer within this community type is perhaps the most difficult to characterize. It is usually dense and diverse, with even small rock outcrops dominated by a variety of species (e.g., *Aquilegia canadensis*, *Micranthes virginiensis*). A few of the characteristic taxa include *Adiantum pedatum*, *Allium tricoccum*, *Anemone acutiloba*, *Aruncus dioicus var. dioicus*, *Asarum canadense*, *Athyrium aspleniodes*, *Cardamine concatenata*, *Carex laxiculmis* var. *laxiculmis*, *C. laxiflora*, *C. plantaginea*, *C. woodii*, *Caulophyllum thalictroides*, *Collinsonia canadensis*, *Dicentra cucullaria*, *Diplazium pycnocarpon*, *Dryopteris* spp., *Festuca subverticillata*, *Geranium maculatum*, *Huperzia lucidula*, *Hydrophyllum virginianum* var. *atranthum*, *Luzula acuminata* var. *carolinae*, *Mitella diphylla*, *Osmorhiza claytonii*, *Panax quinquefolius*, *Persicaria virginiana*, *Poa cuspidata*, *Polygonatum biflorum* var. *biflorum*, *Prosartes lanuginosa*, *Sanguinaria canadensis*, *Sanicula trifoliata*, *Scutellaria saxatilis*, *Tiarella cordifolia*, *Uvularia grandiflora*, and *Viola blanda*.

Low Elevation Dry and Dry-Mesic Forests and Woodlands

4) *Carolina Hemlock Forest* [*Typic Subtype* S2 G2].—This community type is defined by the dominance of *Tsuga caroliniana*, forming a closed or intermittently open canopy due to rocky substrate (Schafale & Weakley 1990). This dominant species is a narrow Southern Appalachian endemic, and like its more widespread sister species, *Tsuga canadensis*, populations are in rapid decline due to the herbivorous invasive Hemlock Woolly Adelgid [*Adelges tsugae* (Annand)]. Both taxa are Federal Species of Concern, but the limited geographic range and population size of *Tsuga caroliniana* makes it more susceptible to extinction. Consequently this community is globally rare, found only in southern Virginia south to northern Georgia along the Southern Appalachians over acidic soils, on steep slopes and bluffs. As noted by Padgett (2011), this community may be fire dependent.

Carolina Hemlock Forest is also rare in Alleghany County, and due to their limited sizes, true well-developed examples of this community do not exist. Most occurrences of this relictual community type are located along the New River palisades near the Virginia border, within New River State Park. Other sites, such as the ridge of Fodderstack Mountain (Doughton Park) along the Blue Ridge Parkway, are very small remnants. Additional interspersed and generally rare canopy species include *Betula lenta* var. *lenta*, *Carya* spp., *Liriodendron tulipifera* var. *tulipifera*, and *Quercus* spp. The subcanopy is almost absent, populated primarily by saplings, while the sparse shrub layer contains species such as *Kalmia latifolia* and *Vaccinium pallidum*. The herb layer is scarce, with rare occurrences of species such as *Goodyera pubescens* and *Mitchella repens*.

5) *Chestnut Oak Forest* [*Dry Heath Subtype* S5 G5; *Herb Subtype* S4 G4G5; *Mesic Subtype* S4? G4].—This is a frequently occurring community type that is most common at low to middle elevations, especially along the Blue Ridge Escarpment and drier south and east-facing slopes within the county. The canopy tends to be closed, but is not particularly dense, and gaps usually occur in very rocky areas. The primary canopy trees include *Quercus montana* as the dominant species, fair amounts of *Q. coccinea*, and occasional *Q. alba* and *Q. rubra*. Other intermittent species include *Acer rubrum* var. *rubrum* and *Carya* spp. Subcanopy trees often include *Amelanchier arborea*, *Cornus florida*, *Crataegus* spp., and *Oxydendrum arboreum*. The shrub layer is variable in density and is usually comprised of species such as *Corylus cornuta*, *Eubotrys recurva*, *Gaylussacia baccata*, *Kalmia latifolia*, *Rhododendron calendulaceum*, *R. catawbiense*, *R. maximum*, *Vaccinium* spp., and *Viburnum acerifolium*. The herb layer is characteristically sparse and exhibits little overall diversity. Frequent components include *Carex appalachica*, *C. pensylvanica*, *C. swanii*, *Chimaphila maculata*, *Coreopsis major* var. *rigida*, *Danthonia compressa*, *D. spicata*, *Dennstaedtia punctilobula*, *Epigaea repens*, *Galax urceolata*, *Galium pilosum*, *Gaultheria procumbens*, *Lespedeza violacea*, *Pteridium aquilinum* var. *latiusculum*, and *Solidago curtisii*.

6) *Granitic Dome Basic Woodland* [S2 G2].—The concept for this community includes forests developed in thin soils over granitic substrates and around the periphery of exfoliated rock outcrops. They are limited to the upper Piedmont. In Alleghany County, this community type is confined to areas atop Stone Mountain's larger granitic domes and a few adjacent slopes, at the base of the Blue Ridge Escarpment. By definition, this community contains some oddly base-rich indicator species that would not be expected to occur over an acidic parent material and there is a general lack of montane species. The canopy is closed to somewhat open, dominated by stunted *Quercus montana*, with interspersed *Carya glabra*, *C. tomentosa*, *Nyssa sylvatica*, and rarely a few *Pinus virginiana*. Per Schafale (2012), *Carya* spp. and *Fraxinus americana* are supposed to be abundant, with oaks generally scarce, thus there is some deviation here from the principal community structure. The subcanopy is essentially absent, while the very sparse shrub layer is occupied by scattered *Gaylussacia baccata*, *Kalmia latifolia*, and *Vaccinium pallidum*. One of the characteristic and most prevalent elements of this community type is its herb layer. This portion of the community lacks diversity and at Stone Mountain, it consists of a near monotypic dense stand of the indicator grass species, *Piptochaetium avenaceum*. Other very rare species include *Carex glaucodea*, *Galax urceolata*, *Hexalectris spicata*, and *Tipularia discolor*.

7) *Montane Oak-Hickory Forest* [*Acidic Subtype* S4S5 G4G5; *Basic Subtype* S3 G3].—Montane Oak-Hickory Forest is widespread through Alleghany County and the mountains of North Carolina. Within the study site, it is most often found along middle to upper slopes just off the Blue Ridge Escarpment, and along inner montane north and east-facing slopes. In contrast to Chestnut Oak Forest, this community occurs in more mesic to sub-mesic, protected sites. As pointed out by Padgett (2011), the soils are variable and range from acidic to somewhat basic, particularly in areas with slight mafic geology. The canopy layer is usually closed and dominated by *Carya cordiformis*, *C. glabra*, *C. ovalis*, and infrequent *C. ovata* and *C. tomentosa*. Oaks also contribute a major component to the canopy layer and include *Quercus alba*, *Q. montana*, and *Q. rubra* var. *rubra*. *Fraxinus americana*, *Magnolia acuminata*, and *M. fraseri* are also usually present in limited amounts. The subcanopy is somewhat dense, comprised of species such as *Amelanchier arborea*, *A. laevis*, *Cornus florida*, *Crataegus macrosperma*, *C. iracunda*, *Hamamelis virginiana* var. *virginiana*, *Ilex montana*, *Menziesia pilosa*, *Ostrya virginiana*, and saplings of other typically canopy-sized trees such as *Acer rubrum var. rubrum*, *Nyssa sylvatica*, and *Oxydendrum arboreum*. The shrub layer is highly variable containing taxa such *Castanea dentata* (sprouts), *Kalmia*

latifolia, *Rhododendron* spp., *Vaccinium* spp. and occasional *Viburnum acerifolium* and *V. prunifolium*, with woody vines such as *Vitis* spp. regularly encountered. The usually sparse to moderately dense herb layer can be rather diverse, with some characteristic species including *Agrostis perennans*, *Aplectrum hyemale*, *Asclepias exaltata*, *Aureolaria laevigata*, *Carex aestivalis*, *C. albicans*, *C. digitalis* var. *digitalis*, *C. pensylvanica*, *Danthonia compressa*, *Dendrolycopodium obscurum*, *Dennstaedtia punctilobula*, *Dichanthelium commutatum var. commutatum*, *Dichanthelium latifolium*, *Dryopteris* spp., *Galium circaezans* var. *circaezans*, *Gentiana austromontana*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Iris cristata*, *Prenanthes* spp., *Scutellaria elliptica* var. *elliptica*, *Veratrum parviflorum*, and *Zizia trifoliata*.

8) *Pine-Oak/Heath* [*High Elevation Subtype* S2 G2; *Typic Subtype* S3 G3].—This community is most prevalent along steep, rocky ridgelines and crests of low to middle elevations, particularly along the edge of the Blue Ridge Escarpment and south-facing portions of adjacent peaks (e.g., Bullhead Mountain, Saddle Mountain). Soils are characteristically dry and very acidic, generally as a consequence of topography, highly exposed habitat, and dominant vegetation. The canopy is quite open and dominated by *Nyssa sylvatica*, *Oxydendrum arboreum*, *Pinus pungens*, *P. rigida*, *P. virginiana*, *Quercus alba*, *Q. coccinea*, and infrequent *Q. velutina*. The subcanopy is essentially absent, but the shrub layer is usually well developed and characterized by species such as *Castanea pumila*, *Comptonia peregrina*, *Eubotrys recurva*, *Gaylussacia baccata*, *Kalmia latifolia*, *Rhododendron* spp., and *Vaccinium pallidum*. The herb layer is sparse, but includes *Aristida dichotoma*, *Epigaea repens*, *Galax urceolata*, *Gaultheria procumbens*, *Melampyrum lineare* var. *americanum*, *Mitchella repens*, *Pteridium aquilinum* var. *latiusculum*, and the woody vines *Smilax glauca* and *S. rotundifolia*.

Rock Outcrop Communities

9) *Low Elevation Granitic Dome* [S2 G2].—This community is defined by large expanses of exfoliating granitic rock with the absence of deep soil pockets and crevices (particularly along steeper sloping portions of the domes) that are usually found on other more fractious rock types. The top of these outcrops are usually flat and conducive to shallow soil accumulation. Where soil is most developed, this community becomes transitional. The largest example of a Low Elevation Granitic Dome in Alleghany County occurs at Stone Mountain State Park, where the presence of several large plutons makes this a site of national significance (Padgett 2011). Other smaller examples are scattered along the Blue Ridge Escarpment. Vegetation occurs in the shallow soil mats of this community type, specifically at the margins of adjacent forested areas and gently sloping pockets. Because of these constraints, no true canopy or subcanopy exists. Rarely shrubs and small trees from neighboring communities (e.g., Granitic Dome Basic Woodland) may become established, yet remain dwarfed and include *Gaylussacia baccata*, *Kalmia latifolia*, *Pinus* spp., *Rhododendron maximum*, and *Vaccinium pallidum*. The primary components of the community occur in the herb layer in thin soils and include species such as *Bulbostylis capillaris, Cyperus retrorsus, Dichanthelium meridionale, Juncus secundus, Linum medium var. texanum, Minuartia glabra, Paronychia fastigiata var. paleacea, Phemeranthus teretifolius, Scleria pauciflora, and Selaginella rupestris.*

10) *Low Elevation Rocky Summit* [*Acidic Subtype* S3 G3?].—This community type occurs in scattered localities throughout Alleghany County at middle to low elevations, generally below 1067 m. It is comprised of exposed ridges of rugged rock outcrops with uneven vertical to sloped faces. This relatively uncommon community type is located along escarpment ridges and along several of the larger mountains within the county such as Bald Knob, Bluff Mountain, Doughton Mountain, and Twin Oaks Mountain, among others. Vegetation in this community is restricted; very little, if any, canopy is present and most plant life is confined to small islands of soil accumulation along the most horizontally oriented surfaces, in crevices of fractured rock, ledges, and near cliff bases. Higher elevation species are generally lacking. This open canopied community may occasionally support, in areas with deeper soils, shrubs and small trees (usually stunted) in areas with deeper soils such as *Chionanthus virginicus*, *Clethra acuminata*, *Eubotrys recurva*, *Pinus pungens*, *Salix humilis*, *Sorbus americana*, *Chionanthus virginicus*, *Vaccinium erythrocarpum*, and *V. stamineum*. The herbaceous layer is localized and often contains species such as *Andropogon virginicus* var. *virginicus*, *Avenella flexuosa*, *Campanula divaricata*, *Capnoides sempervirens*, *Carex rugosperma*, *Coreopsis* spp., *Crocanthemum canadense*, *Danthonia spicata*, *Helianthus divaricatus*, *Heuchera villosa* var. *villosa*, *Hydatica petiolaris*, *Hylotelephium telephiodes*, *Hypericum gentianoides*, *Schizachyrium scoparium* var. *scoparium*, *Selaginella rupestris*, and *Woodsia* spp.

11) *Montane Cliff* [*Acidic Herb Subtype* S3 G3G4].—The community type is defined by steep rock faces and slopes that accumulate soil in small fissures, ledges, and talus. Ultimately, the sheer slope of this community type eliminates the potential for canopy development, and much of the cliff face is barren except for bryophytes and lichens. Most canopy species are found along the periphery of these cliffs, providing some indirect shading. These sites usually occur near the top of dry ridges and peaks and abruptly descend into mesic forests at their bases. They occur throughout Alleghany County, usually as small isolated examples, but are most frequent in watershed areas of the New River and adjacent tributaries, as well as north-facing slopes of some of the higher peaks. Sparse vascular vegetation is limited to an herb layer and often consists of characteristic species such as *Asplenium montanum*, *A. trichomanes* ssp. *trichomanes*, *Heuchera villosa* var. *villosa*, *Micranthes caroliniana*, and *Polypodium appalachianum*.

12) *Low Elevation Acidic Glade* [*Grass Subtype* S1S2 G1G2].—Occurrences in Alleghany of this community type are few, and limited to small patchy areas surrounding and often associated with or transitional to Low Elevation Rocky Summit communities. This community is characterized by gently to moderately sloping rock outcrops with shallow soils and few crevices supporting a predominance of graminoids, scattered low shrubs, and sparse small trees. As implied, the canopy is open, allowing for high light exposure. Some of the rarely occurring small or stunted trees and shrubs in this community type include species such as *Crataegus macrosperma*, *Diospyros virginiana*, *Quercus montana*, and *Vaccinium* spp. Vegetation mats are often accompanied by lichens (*Cladonia* spp.) and consist of species such as *Andropogon virginicus* var. *virginicus*, *Carex tonsa*, *C. umbellata*, *Cyperus lupulinus* var. *lupulinus*, *Danthonia compressa*, *D. spicata*, *Festuca rubra* var. *rubra*, *F. trachyphylla*, *Schizachyrium scoparium* var. *scoparium*, and *Selaginella rupestris*. Though dominated by graminoids, this community type also harbors the rare occurrence of sexual diploids of *Erigeron strigosus* and the only known locality for *Polygonum tenue* in the county. One of the best examples of this community type occurs at Bluff Mountain, while additional smaller sites are scattered.

Rivers and Floodplains

13) *Montane River Aquatic* [N/A].—This community is described here to accommodate for fully aquatic vegetation within montane river systems. It is perhaps best treated in or at least affiliated with the Rocky Bar and Shore community complex, as it shares affinities with the Rocky Bar and Shore (Riverweed Subtype). As stated by Schafale (2012), the Riverweed Subtype "covers largely-submerged riffles where *Podostemum ceratophyllum* dominates, generally in nearly monospecific stands" and "this community is more aquatic than the other subtypes, and may warrant a separate community type." This community subtype currently lacks a state rank, but is considered G3G5 globally. I concur that it seems distinctive, and here modify and expand the concept to include the presence of other aquatic vegetation in addition to Riverweed. As defined here, this community contains plants rooted in alluvial soils or attached to rocky substrates within larger rivers, often away from neighboring riparian zones. Plants are primarily submerged or rooted-floating herbaceous species in moderately to swiftly-flowing waters, with a general lack of any emergent taxa. This community type notably occurs within the Little River, South Fork of the New River, and the New River itself. Characteristic aquatic species include: *Elodea canadensis*, *Podostemum ceratophyllum*, *Potamogeton epihydrus*, and *Vallisneria americana*.

14) *Rocky Bar and Shore* [*Alder-Yellowroot Subtype* S3 G3G4].—This community is primarily found along the South Fork of the New River and the New River proper, in the vicinity of river banks, but also as exposed river islands. The best examples of this community type include areas that have either gravel or bolder deposits, or soil accumulations in rock outcrops. These riparian zones also include eroded cuts or channeling, but characteristically include gravel and scour bars that are too regularly disturbed via periodic flooding to support a canopy or understory layer, but often leave demonstrable alluvial deposits. Trees are absent to rare and include, *Platanus occidentalis* and *Salix nigra*. Shrubs and small trees characteristic of these areas include *Alnus serrulata*, *Cornus amomum*, *Physocarpus opulifolius* var. *opulifolius*, *Salix sericea*, *Xanthorhiza simplicissima*, and woody vines such as *Vitis labrusca* and *V. vulpina*. Herb layer vegetation is highly variable and fleeting in this community type, but often includes *Boykinia aconitifolia*, *Carex* spp., *Cyperus flavescens*, *Eleocharis* spp., *Equisetum arvense*, *Glyceria striata* var. *striata*, *Hypericum mutilum* var. *mutilum*, *Impatiens capensis*, *I. pallida*, *Juncus*

spp., *Lobelia cardinalis*, *Ludwigia palustris*, *Myosotis scorpiodes*, *Persicaria pensylvanica*, *P. puncata*, and *Scutellaria lateriflora*, among others. Some invasive exotics (e.g., *Arthraxon hispidus* var. *hispidus* and *Microstegium vimineum*) can be found in this community type, presumably due to regular disturbance via river scouring. A few small areas along the Little River and Prathers Creek approach the Twisted Sedge Subtype, however *Carex torta* is not notably dominant at these sites.

15) *Montane Alluvial Forest* [*Small River Subtype* S1 G3].—This community is found in floodplains and slopes along major tributaries within the county. Although it contains an amalgamation of cove and floodplain species, it is the presence of this latter group of indicator taxa, coupled with a regular flooding regime that distinguishes this community from Rich Cove Forests and Acidic Cove Forests. The best current examples occur in areas adjacent to rivers that have steep slopes, below rocky cliffs that are for the most part agriculturally inaccessible. It was formerly much more common, but the rich alluvium in riparian areas is prized by farming, while the remainder of riverside landscape has fallen to other industries including construction and timber production. Important mesophytic canopy species that contribute a relatively dense cover include *Acer rubrum* var. *trilobum*, *Aesculus flava*, *Betula alleghaniensis*, *Liriodendron tulipifera* var. *tulipifera*, *Platanus occidentalis*, *Populus ×jackii*, and *Tsuga canadensis*. Characteristic subcanopy and shrub layer taxa are *Acer negundo* var. *negundo*, *Carpinus caroliniana* var. *virginiana*, *Prunus americana*, *Ptelea trifoliata* var. *trifoliata*, *Rhododendron arborescens*, *R. maximum*, *Sambucus canadensis*, *Tilia americana* var. *heterophylla*, *Viburnum prunifolium*, and *Xanthorhiza simplicissima*. The herb layer is generally dense and comprised of many cove species, as well as other taxa including *Boehmeria cylindrica*, *Dichanthelium* spp., *Glyceria* spp., *Heracleum maximum*, *Impatiens* spp., *Leersia* spp., *Packera aurea*, and *Viola* spp.

Nonalluvial Wetlands

One of the most important natural aspects of Alleghany County is its possession of numerous nonalluvial wetlands. As stated by Padgett (2011), this small county contains "some of the best examples of Southern Appalachian Bog and Swamp Forest-Bog Complex natural communities in the state and the nation." He continues by enumerating a few exemplars including Brush Creek Bog, Laurel Branch Bog, Skunk Cabbage Bog, and Sparta Bog. These wetlands are inherently fed by small spring seeps that are themselves uncommon and rather unique communities. This hydrological and ecological community interdependence is a frail example of the synergistic nature of our natural heritage. Consequently, the following communities are some of the most imperiled in North Carolina, largely due to agriculture and residential development.

16) *Low Elevation Seep* [*Montane Subtype* S2S3 G2G3].—Seeps are frequent scattered elements of the county, often originating on mountain or hillsides and draining into low lying wetlands or other tributaries. Many of the larger examples include very small woodland streams that spread out in lowlands creating seepage bogs. This community type is transitional to a Rich Montane Seep, but generally lacks rich higher elevation indicator species found in this community. Species composition is otherwise quite variable. Soils are often a mixture of rocky intermittent stretches and mucky saturated areas. The canopies of Low Elevation Seep communities are usually closed, with only the most inundated areas with gaps. Common mesic trees include *Acer rubrum* var. *rubrum*, *Aesculus flava*, *Betula lenta* var. *lenta*, *Liriodendron tulipifera* var. *tulipifera*, *Magnolia acuminata* var. *acuminata*, *Quercus rubra* var. *rubra*, and *Tilia americana* var. *heterophylla*. Subcanopy and shrub layer species include sparse *Clethra acuminata*, *Ilex montana*, *Kalmia latifolia*, *Oxydendrum arboreum*, *Rhododendron* spp., and *Vaccinium* spp. Herbaceous vegetation is distinctive, occurring on mounds, in rock crevices, and in muddy margins of the seep composed of species such as *Cardamine bulbosa*, *C. flagellifera* var. *flagellifera*, *C. pensylvanica*, *C. rotundifolia*, *Carex bromoides* ssp. *montana*, *C. prasina*, *C. scabrata*, *C. stipata* var. *stipata*, *Chelone glabra*, *Deparia acrostichoides*, *Glyceria melicaria*, *Hydrocotyle americana*, *Juncus* spp. (one site with *J. gymnocarpus*), *Micranthes micranthidifolia*, *Thalictrum clavatum*, *Trautvetteria caroliniensis* var. *caroliniensis*, *Trillium sulcatum*, *Veratrum viride*, rarely *Veronica americana*, common *Viola cucullata*, and *V. macloskeyi* ssp. *pallens*.

17) *Southern Appalachian Bog* [*Low Elevation Subtype* S1S2 G1G2; *Skunk Cabbage Subtype* S1 G1; *Typic Subtype* S1S2 G1G2].—According to Padgett (2011) this general community type is restricted to the mountains of North Carolina, Tennessee, and Virginia. These communities occur throughout the county, particularly

along the Blue Ridge Parkway, NC 18 and US 21. Vegetation within these sites is very zonal with an absence of canopy species, encroaching shrubs that are also interspersed throughout in lesser amounts, and distinctive tussocks of graminoids and herbs that form an open inundated meadow. These communities serve as refugia for many northern and coastal disjunct species, further adding to their uniqueness and varying in quality, with the most altered examples containing few if any rare species and simply transitional to a degraded wet-meadow. Substrate is variable, with many of Alleghany County's bogs occurring over mafic rock, or in the case of Savannah Church Bog, over ultramafic rock that imparts some fen-like qualities to the vegetation. Commonly encountered shrubs and trailing woody species include *Alnus serrulata*, *Aronia* spp., *Hypericum densiflorum*, *H. prolificum*, *Kalmia carolina*, *Lindera benzoin*, *Lyonia ligustrina*, *Rhododendron viscosum*, *Rosa palustris*, *Salix sericea*, *Spiraea alba*, *S. latifolia*, *Vaccinium fuscatum*, *V. macrocarpon*, and *Viburnum cassinoides*. Herbs and graminoids are especially diverse, with some consisting of *Andropogon glomeratus var. glomeratus*, *Apios americana*, *Bartonia virginica*, *Calamagrostis canadensis var. canadensis*, *C. coarctata*, *Calopogon tuberosus* var. *tuberosus*, *Carex atlantica*, *C. buxbaumii*, *C. echinata* ssp. *echinata*, *C. stricta*, *C. styloflexa*, *Chelone cuthbertii*, *Cicuta maculata* var. *maculata*, *Dichanthelium lucidum*, *Drosera rotundifolia* var. *rotundifolia*, *Eleocharis* spp., *Epilobium leptophyllum*, *Eriocaulon decangulare* var. *decangulare*, *Eriophorum virginicum*, *Galium asprellum*, *Gentiana saponaria*, *Glyceria laxa*, *Juncus brevicaudatus*, *J. longii*, *J. subcaudatus*, *Linum striatum*, *Lysimachia terrestris*, *Osmunda* spp., *Osmundastrum cinnamomeum*, *Oxypolis rigidior*, *Panicum virgatum* var. *virgatum*, *Parnassia* spp., *Platanthera* spp., *Polygala cruciata* var. *aquilonia*, *Pycnanthemum* spp., *Rhynchospora* spp., *Sanguisorba canadensis*, *Scleria* spp., *Selaginella apoda*, *Stenanthium gramineum* var. *robustum*, *Thalictrum macrostylum*, *Thelypteris palustris* var. *pubescens*, and *Xyris torta*.

18) *Swamp Forest-Bog Complex* [*Typic Subtype* S2 G2].—This community type shares many affinities with Southern Appalachian Bogs. The primary difference is in the physiognomy of these areas, which exhibits a complex matrix of dense wooded thickets with intermittent small openings that correspondingly vary from shade tolerant to shade intolerant species. As with bogs, they are mostly restricted to bottomlands. These communities are considered to be drier than bogs, yet this varies considerably. The most common occurrences of Swamp Forest-Bog Complex can be found along the Blue Ridge Parkway neighboring some of the streams (e.g., Brush Creek, Big Pine Creek) that parallel this road. Canopies often contain species such as *Acer rubrum var. rubrum*, *Pinus rigida*, *P. strobus*, and *Tsuga canadensis*, with rare occurrences of *Magnolia tripetala*. The subcanopy and shrub layers intergrade and include species such as *Alnus serrulata*, *Hypericum densiflorum*, *Ilex verticillata*, *Kalmia carolina*, *K. latifolia*, *Rhododendron maximum*, *Sambucus canadensis*, *Toxicodendron vernix*, and *Viburnum nudum*. Species often encountered within the herb layer are *Arisaema triphyllum* ssp. *stewardsonii*, *Carex bullata*, *C. folliculata*, *C. gynandra*, *C. intumescens* var. *intumescens*, *C. laevivaginata*, *C. longii*, *Cinna arundinacea*, *Dryopteris cristata*, *Festuca subverticillata*, *Houstonia serpyllifolia*, *Osmunda claytoniana*, *Osmundastrum cinnamomeum*, *Onoclea sensibilis* var. *sensibilis*, *Rubus dalibarda*, *R. hispidus*, and *Symplocarpus foetidus*.

DISTURBED COMMUNITIES

Culturally disturbed and ruderal communities are prevalent within the county. These areas are exemplified by urbanization, roadsides and ecotones, residential lawns, annual crop lands, Christmas tree plantations, and any other areas maintained by regular human activity. Due to the complex nature of these communities, larger associations are not given.

19) *Plantations*.—This community category refers to areas of woody plant cultivation for agroeconomical purposes. More specifically, these farms include regularly spaced plantings of *Abies concolor*, *A. fraseri*, *Buxus sempervirens*, *Pinus strobus*, and other species that are harvested after several years of growth and maintenance. Intermittent vegetation is usually comprised of exotic annual and perennial grasses such as *Digitaria sanguinalis* and *Schedonorus arundinaceus*, as well as an assortment of exotic herbs such as *Arctium minus*, *Cerastium* spp. and *Stellaria media*, and native weedy species such as *Ambrosia artemisiifolia* and *Chenopodium album*.

20) *Agricultural Fields and Farms*.—In contrast to a plantation, this community category accommodates both agricultural fields that experience an annual harvest of crops and regular tillage practices and less regularly tilled fallow fields. In addition, this community refers to farm areas that harbor livestock (e.g., cattle and

hogs) in a localized and heavily disturbed environment. Many of the species encountered in this community are exotic adventives that are introduced from the previous year's crop rotation (e.g., *Zea mays* ssp. *mays*), are weedy naturalized species that reseed themselves (e.g., *Amaranthus* spp.) or reemerge from perennial rootstock (e.g., *Convolvulus arvensis*). Likewise, weedy species are often inadvertently introduced as feed contaminants for livestock (e.g., *Marrubium vulgare*) or seed and have ultimately become established elsewhere in the county (e.g., *Silene flos-cuculi* ssp. *flos-cuculi*).

21) *Meadows, Pastures, and Ecotones.*—Sites conforming to this designation refer to any area that exhibits a predominance of graminoids (Cyperaceae, Juncaceae, and Poaceae) and composites (Asteraceae) that are either maintained irregularly, with some succession allowed to occur (meadows), or are utilized for grazing cattle and mowed one to several times annually for hay feed (pastures). In contrast to an agricultural field, soils remain less disturbed. Reminiscent of plantations, they usually contain a predominance of annual and exotic perennial grasses, but often also have native graminoids regularly interspersed within the site. In Alleghany, pastures and meadows often abut tributaries and comprise the floodplains of these waterways. Such areas are frequently wet, with partially inundated mid-field depressions. Sites like this are most common along the New River and Little River and their associated tributaries. These wet meadows are sometimes transitional to Southern Appalachian Bogs, and in addition to exotics, they often contain native species such as *Carex frankii*, *C. styloflexa*, *Leersia oryzoides*, *Lilium grayii*, *Mimulus ringens* var. *ringens*, *Scirpus cyperinus*, *S. expansus*, *S. polyphyllus*, and *Spartina pectinata*. In other areas, pastures are commonly surrounded by woodlands and are ecotonal around their perimeters. Upland taxa, particularly small native trees such as *Crataegus* spp. and *Malus coronaria* notoriously occur in these habitats.

22) *Roadsides, Power Line Corridors, and Ecotones.*—These areas are highly generalized and account for a wide array of vegetation patterns. As with pastures bordering tributaries, roadsides are quite often periodically flooded and wetland-like. Included within this community type are flat gravelly roadside shoulders, drainage ditches, and woodland ecotones. As a consequence of this tremendous variability, these sites often contain both exotic and native taxa, the latter of which are introduced from bordering natural communities. Drainage ditches are particularly important as they can harbor hydrophilic native taxa such as *Carex lurida*, *Persicaria hydropiper*, *Schoenoplectus tabernaemontani*, and *Scirpus hattorianus*. In contrast, the physical instability of this community type exposes it to the introduction (perhaps vehicular in some cases) of adventives (e.g., *Sorghum bicolor* var. *bicolor* and *Tagetes* spp.) and other naturalized exotics. Woodland borders and embankments are especially important as they provide open habitat for native taxa such as *Desmodium* spp., *Helianthus atrorubens*, *Lespedeza* spp., *Phlox* spp., *Physostegia virginiana* ssp. *praemorsa*, *Spiranthes cernua*, and *Veronicastrum virginicum*. Power line corridors are often similar to meadows, yet contain considerable small shrubs and stump sprouts from periodic clearing procedures. Most taxa within these sites are native successional species.

23) *Old Homesteads.*—Like any area that has been inhabited for long periods of time, Alleghany County contains several homesites and lots that have been abandoned and allowed to dilapidate. In many cases, the former foundation and/or chimney of a house may be visible. In other situations, only the level area and surrounding vegetation provide evidence of a possible human-derived structure. In any case, these sites often contain cultivated species that have either remained persistent (e.g., *Chaenomeles speciosa*, *Cunninghamia lanceolata*, *Thuja occidentalis*, and *Viburnum opulus* var. *opulus*) or appear to have spread, mostly vegetatively, to surrounding areas (e.g., *Aster tataricus* and *Lycium chinense*). One aspect of this community category that is particularly interesting is that it provides some insight into the historical preference of cultivated species in the county.

24) *Residential and Urban Areas*– This community differs from well maintained pastures and old homesteads in regard to the close anthropogenic activity associated with it. In essence, residential areas are comprised of lawns, urban areas, and disturbed areas around gardens that provide habitat for the infiltration of exotics, particularly those cultivated for aesthetic and/or consumption purposes. These introduced taxa may readily, but sparingly become naturalized in small exposed areas adjacent to their point of origin. In some cases, homes and yards are developed around streams, often allowing for the establishment of exotic wetland

species (e.g., *Glyceria declinata*, *Nasturtium officinale*). Examples of weakly escaping or naturalized species include herbaceous exotic taxa like *Aegopodium podagraria*, *Antirrhinum majus*, *Chionodoxa luciliae*, and even woody species like the native tree *Crataegus phaenopyrum* or exotic shrub *Prunus tomentosa*. Similarly, many rural residences have vegetable gardens and waste heaps that occasionally provide a source of inoculation for species such as *Solanum lycopersicum* and *S. tuberosum*. Mulch beds also occasionally harbor adventives introduced from intercalated seeds that sporadically germinate.

25) *Ponds and Reservoirs*.—This community includes all manmade bodies of water within the county, and is treated here mainly because of their anthropogenic origin. These areas include small ponds and larger lakes of various sizes. Lake Louise, located at Roaring Gap Club, is the largest reservoir in the county (Figs. 1 & 3). It was constructed in 1927, and other than general maintenance and recreational use, it has received little alteration. It was built in close proximity to several known bogs and harbors many taxa around its margins with bog-like affinities. Consequently, this lake and the vegetation that surrounds it are likely relicts of a once natural community. Little Glade Mill Pond and Hare Mill Pond along the Blue Ridge Parkway are other examples of such communities. The semi-natural aspect of these sites is problematic for classification purposes, and they appear to be closely associated with Piedmont/Mountain Semipermanent Impoundment communities (Schafale & Weakley 1990; Schafale 2012). Though many taxa found in these areas are exotics that are capitalizing on the open environment, most are native. Serial wetland strata in this community include open water, free-floating herbaceous species such as *Lemna minor*, rooted floating herb species exemplified by *Callitriche heterophylla* var. *heterophylla* and *Potamogeton diversifolius*, and submerged to emergent taxa such as *Isoetes valida* and *Schoenoplectus purshianus*. Margins of these water bodies transition to wet, sedge meadows dominated by species such as *Carex atlantica*, *C. leptalea* var. *leptalea*, *Cyperus bipartitus*, *Juncus acuminatus*, and *Scirpus* spp. These portions are the most bog-like and often contain many infrequent to rare taxa such as *Carex canescens* var. *canescens*, *Eleocharis palustris*, and *Juncus brevicaudatus*. Other notable non-graminoid herbs include *Liparis loeselii*, *Lysimachia terrestris*, *Triadenum virginicum*, and *Spiranthes lucida*. Woody species are less common, but usually include *Alnus serrulata*, *Hypericum densiflorum*, and *Spiraea tomentosa*.

Disturbance

As noted by Padgett (2011), Alleghany County contains a large number of Significant Natural Heritage Area (SNHA) tracts for such a small county. Forty-eight SNHAs have been identified, four of which are Nationally Significant, 21 that are State Significant, 15 of Regional Significance, and seven that are ranked as County Significant. This high number of SNHAs stands in stark contrast to the larger picture of overall heavy land use in the county, which would suggest that this area would have far fewer areas of significance than it currently possesses.

Though this area is not dominated by urbanization, the demands of agriculture have ultimately contributed to a greatly disturbed landscape, as further evidenced by the large number of exotic species found here, as well as propensity for some of these to be highly invasive. Moreover, the most distressing aspect of anthropogenic activity in Alleghany County is perhaps the obvious reduction in local montane wetlands. This is particularly evident in the numerous bog-like remnants that have been converted to farmland through ditching/draining practices throughout the area. To further complicate matters, the dynamic nature and complex vegetation of these natural communities is not well resolved (Wichmann 2009) in the midst of severe decline.

According to Murdock (1994), wetlands harbor at least one-third of the threatened and endangered species in the United States, and the non-alluvial wetlands of the mountains are quite small on average (usually under 4.05 ha). Southern Appalachian Bogs and Swamp Forest-Bog Complexes are particularly important due to their rarity and the fact that these rather disparately located communities harbor many plants that are not only uncommon in general, but are often found in no other community type. The destruction of these fragile habitats has reduced the natural area quality in Alleghany County. Weakley and Schafale (1994) estimated that only 23% of the Southern Appalachian Bogs in North Carolina still contain their natural vegetation, while only 10% of the natural vegetation remains in Swamp Forest-Bog Complexes (Typic Subtype). The once prolific natural wetlands of Alleghany County have been reduced to a few small sites (e.g., Sparta Bog, Brush Creek

TABLE 5. Auxiliary list of taxa recognized in the Alleghany County flora that deviate from the primary source of taxonomic concepts (Weakley 2011). See text and Table 6 for definitions of origin symbols.

Family	Origin	Taxon	Concept Source	Difference from Weakley (2011)
Pinaceae	†	Abies concolor	FNA (1993+)	Not included
Cupressaceae	†	Callitropsis ×leylandii	USDA, NRCS (2012)	Not included
Campanulaceae	‡	Campanula punctata	Bailey (1924)	Not included
Cyperaceae	Native	Carex gracillima × C. virescens	R.F. C. Naczi (pers. comm.)	Tentative hybrid not treated
Cupressaceae	†	Chamaecyparis lawsoniana	FNA (1993+)	Not included
Cupressaceae	†	Chamaecyparis pisifera	Rehder (1937)	Not included
Asteraceae	‡	Coreopsis lanceolata aff. var. villosa	FNA (1993+)	Vars. not treated
Rosaceae	†	Cotoneaster aff. horizontalis	Rehder (1937)	Not included
Rosaceae	Native	Crataegus chrysocarpa var. dodgei	Poindexter & Lance (2011)	Included, but infraspecific treatment necessary
Plantaginaceae	†	Digitalis purpurea L. cv. 'Campanulata'	Bailey & Bailey (1976)	Cultivars not recognized
Poaceae	‡	Eragrostis tef	FNA 1993+	Included but not yet keyed
Asteraceae	Native	Erigeron strigosus var. nov.?	R. D. Noyes (pers. comm.)	Morphologically distinctive sexual diploid potentially deserving infraspecific rank
Euphorbiaceae	∞	Euphorbia dulcis cv. 'Chameleon'	Stace (2010)	Species not included; cultivar deduced from popular horticultural websites
Geraniaceae	Native	Geranium carolinianum	Weakley (2011)	Not treated here at the infraspecific level due to difficulty applying concepts
Malvaceae	†	Hibiscus moscheutos L. cv. 'Disco Belle'	Various popular horticultural websites	Cultivars not recognized
Hyacinthaceae	∞	Hyacinthoides ×massartiana	Stace (2010)	Not included
Hydrangeaceae	†	Hydrangea arborescens var. grandiflora	Bailey (1924)	Vars. not treated
Brassicaceae	†	Iberis sempervirens	FNA (1993+)	Included, but not yet keyed
Cupressaceae	†	Juniperus horizontalis	FNA (1993+)	Not included
Xanthorrhoeaceae	†	Kniphofia uvaria	Bailey (1924)	Not included
Orchidaceae	Native	Liparis ×jonesii	Bentley (2000)	Hybrids not recognized
Lamiaceae	Native	Lycopus ×sherardii	Henderson (1962)	Hybrids not recognized
Magnoliaceae	†	Magnolia ×soulangiana	Bailey (1924)	Hybrids not recognized
Rosaceae	†	Malus cf. sieboldii	Rehder (1937)	Not included
Nyctaginaceae	∞	Mirabilis jalapa cv. 'Broken Colors'	Various popular horticultural websites	Cultivars not recognized
Poaceae	**	Miscanthus sinensis var. variegatus	Bailey & Bailey (1976)	Vars. not treated, briefly alluded to
Poaceae	Native	Muhlenbergia schreberi var. palustris	Hitchcock & Chase (1950)	Vars. not treated, but this entity appears distinctive
Vitaceae	Native	Muscadinia rotundifolia var. rotundifolia	Weakley et al. (2011)	Nomenclatural/taxonomic change
Poaceae	Native	Paspalum floridanum ×P. leave	R.J. Leblond (pers. comm.)	Tentative hybrid not treated
Santalaceae	Native	Phoradendron leucarpum ssp. leucarpum	Abbott & Thompson (2011)	This name has priority and proper combination
Pinaceae	†	Picea pungens	FNA (1993+)	Not included
Salicaceae	†	Populus maximowiczii	Bailey & Bailey (1976)	Not included

TABLE 5. continued.

Family	Origin	Taxon	Concept Source	Difference from Weakley (2011)
Lamiaceae	Native	*Pycnanthemum arkansanum*	Grant & Epling (1943)	Cursory examination of type images suggest that this taxon is valid
Rosaceae	†	*Rosa* sp.	—	Unresolved taxon of uncertain origin
Asteraceae	‡	*Rudbeckia hirta* cv. 'Gloriosa Daisy'	Bailey & Bailey (1976)	Cultivars not recognized
Caryophyllaceae	∞	*Saponaria ocymoides*	FNA (1993+)	Not included
Lamiaceae	Native	*Stachys appalachiana*	Poindexter & Nelson (2011)	Included as *Stachys* sp. 3, but name not formally published
Asteraceae	Native	*Symphyotrichum* aff. *novi-belgii*	J.C. Semple (pers. comm.)	Potentially new and aligned with this species
Asteraceae	Native	*Symphyotrichum* aff. *undulatum*	J.C. Semple (pers. comm.)	Potentially new species or variety
Asteraceae	Native	*Symphyotrichum* sp. (subsect. *Dumosi*)	J.C. Semple (pers. comm.)	Unresolved identity, but a unique taxon to the flora
Trilliaceae	Native	*Trillium sulcatum* fo. *albolutescens*	Patrick (1984)	Forms not recognized
Ericaceae	Native	*Vaccinium stamineum*	Weakley (2011)	Not treated here at the infraspecific level due to difficulty applying concepts

Bog, and Skunk Cabbage Bog) while remnants of natural wetlands are apparent by numerous disturbed meadow bog communities. Although these disturbed areas still harbor a few rare plants (as noted by Weakley and Schafale 1994), they are a bleak reminder of the enormous human impact on the natural heritage of this county.

ANNOTATED CHECKLIST

Nomenclature and plant origin (exotic vs. native) follow Weakley (2011) except where taxa were recently described, have new nomenclatural combinations, follow a different taxonomic concept, or are not currently recognized as occurring in the southeast or mid-Atlantic states (see Table 5). Plants of questionable nativity in Weakley (2011) are assigned status based on the PLANTS Database (USDA NRCS 2012). Along with traditional infraspecific ranks of variety and subspecies, three forms, five cultivars, and four potentially novel taxa are recognized in the flora to either aid in the identification of these plants or because they also demonstrate some geographic affinities that imply need for further study. Taxa are arranged alphabetically within each major clade by family, genus, and species. Authorities are abbreviated according to the Brummitt and Powell (1992) scheme, which is continuously updated and available online (Harvard University Herbaria 2012). Major clade organization follows the PhyloCode as derived from Cantino et al. (2007) rather than a linear system (e.g., Reveal 2012) to better reflect phylogenetic relationships and includes four primary groups: LYCOPODIOPHYTA, MONILOPHYTA, ACROGYMNOSPERMAE, and ANGIOSPERMAE (here consisting of the Monocotyledoneae, Nymphaeales, Magnoliidae, and Eudicotyledoneae).

The scientific name of each taxon is preceded by a symbol denoting origin and invasive status as: naturalized exotic (*), invasive exotic (**), adventive exotic (‡), exotic persistent from cultivation (†), native persistent from cultivation (Δ), taxa that appear to have escaped or are weakly spreading from cultivation (∞ = exotic, □ = invasive, ^ = native), or a lack of notation for naturally occurring native taxa. The scientific name is then followed by putative record status including: previously published state record (+), new state record (++), and county record (○), where applicable. "Significantly Rare" taxa (see Table 2) are in **bold type,** and "Watch List" taxa are underlined. A primary community of occurrence, a relative abundance value, representative voucher specimen number(s), and respective repository conclude each taxon entry. An italicized voucher specimen(s) number by the author is in a *year-number* (e.g., *08-274*) format and corresponds to the primary collection

TABLE 6. Symbology and abbreviations used in the checklist of vascular plants known from Alleghany County, North Carolina.

Symbols

Origin Status
* = Naturalized Exotic
** = Invasive Exotic
‡ = Adventive Exotic
† = Exotic Persistent From Cultivation
∞ =Exotic Escaped From Cultivation
□ =Invasive Escaped From Cultivation
Δ = Native Persistent From Cultivation
^ ^ = Native Escaped From Cultivation

Record and Rarity Status
+ = Previously Published State Record
++ = New State Record
○ = County Record
bold = "Significantly Rare"
underlined = "Watch List"

Relative Abundance

V = Very Rare
R = Rare
S = Scarce
I = Infrequent
O = Occasional
F = Frequent
A = Abundant
X = Presumably Extirpated
U = Unknown

Plant Communities

High Mountain Communities
1 = High Elevation Red Oak Forest

Low Elevation Mesic Forest
2 = Acidic Cove Forest
3 = Rich Cove Forest

Low Elevation Dry and Dry-Mesic Forests and Woodlands
4 = Carolina Hemlock Forest
5 = Chestnut Oak Forest
6 = Granitic Dome Basic Woodland
7 = Montane Oak-Hickory Forest
8 = Pine-Oak/Heath

Rock Outcrop Communities
9 = Low Elevation Granitic Dome
10 = Low Elevation Rocky Summit
11 = Montane Cliff
12 = Low Elevation Acidic Glade

Rivers and Floodplains
13 = Montane River Aquatic*
14 = Rocky Bar and Shore
15 = Montane Alluvial Forest

Nonalluvial Wetlands
16 = Low Elevation Seep
17 = Southern Appalachian Bog
18 = Swamp Forest-Bog Complex

*Disturbed Communities**
19 = Plantations
20 =Agricultural Fields and Farms
21 = Meadows, Pastures, and Ecotones
22 = Roadsides, Power Line Corridors, and Ecotones
23 = Old Homesteads
24 = Residential Areas
25 = Ponds and Reservoirs

Note: Communities are general and follow Schafale and Weakley (1990) and Schafale (2012). (*) = informally recognized community types. Table format is adapted from Estes (2005).

housed at the Appalachian State University Herbarium (BOON). Taxa represented by collections from other individuals are identified by the collector's name and number, along with respective repository and date of collection in brackets (e.g., *J.L. Michael 792* [NCU, 25 June 1968]). Herbarium acronyms follow Index Herbariorum (Thiers, continuously updated).

Unvouchered records derived solely from the Flora of the Southeast Atlas (2012) are indicated with a source reference: 1) "*FSE-CVS*" = Carolina Vegetation Survey data, and 2) "*FSE-RAB*" = Radford et al. (1968). Similar records from the North Carolina Natural Heritage Program, though also partially integrated into the Flora of the Southeast Atlas (2012) database, are represented separately as "*NCNHP*" due to rarity status. These collective literature and sight reports are unverified and should be acknowledged with caution. Taxa that are derived from these three sources are not included in the taxonomic summary.

Relative abundance is assigned here as inclusive for the entire study site and is adapted from Murrell and Wofford (1987) and Estes (2005): Very Rare (V) = found in a single locale, usually in a small population; Rare (R) = known from one to two localities, in small to moderate populations; Scarce (S) = several small or one to two moderate to large populations; Infrequent (I) = scattered throughout in many small populations, or several

moderate to large populations; Occasional (O) = well distributed in many small to moderate populations or in few localized very large populations; Frequent (F) = generally encountered throughout with regularity in populations of various sizes; Abundant (A) = characteristic and dominant in many sites; Extirpated (X) = taxon presumed to be no longer extant; and Unknown (U) = status of taxon is unverified. A guide to the abbreviations and symbology used in the list is presented in Table 6.

LYCOPODIOPHYTA

Isoetaceae

Isoetes valida (Engelm.) Clute – 25; S; 10-186

Lycopodiaceae

Dendrolycopodium hickeyi (W.H. Wagner, Beitel, & R.C. Moran) A. Haines – 18; R; 09-603
Dendrolycopodium obscurum (L.) A. Haines – 7; F; 08-919
Diphasiastrum digitatum (Dill. ex A. Braun) Holub – 7; A; 10-14
Diphasiastrum tristachyum (Pursh) Holub ○ – 12; R; 09-895
Huperzia lucidula (Michx.) Trevis. – 3; F; 08-763
Lycopodium clavatum L. ○ – 8; V; 08-1239

Selaginellaceae

Selaginella apoda (L.) Spring – 17; I; 09-254
Selaginella rupestris (L.) Spring – 9; I; 08-147

MONILOPHYTA

Aspleniaceae

Asplenium montanum Willd. – 11; O; *08-692*
Asplenium platyneuron (L.) Britton, Sterns, & Poggenb. – 2; F; *08-278*
Asplenium rhizophyllum L. ○ – 3; R; *08-861*
Asplenium trichomanes L. ssp. *trichomanes* – 11; O; *08-02*

Athyriaceae

Athyrium asplenioides (Michx.) A.A. Eaton – 3; F; *08-1345*
Deparia acrostichoides (Sw.) M. Kato – 16; O; *08-1146*
Diplazium pycnocarpon (Spreng.) M. Broun ○ – 3; S; *08-758*

Blechnaceae

Woodwardia areolata (L.) T. Moore – 25; V; *10-427*

Cystopteridaceae

Cystopteris protrusa (Weath.) Blasdell – 3; O; *08-691*

Dennstaedtiaceae

Dennstaedtia punctilobula (Michx.) T. Moore – 7; A; *08-276*
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw. ex A. Heller – 22; F; *08-1111*

Dryopteridaceae

Dryopteris carthusiana (Vill.) H.P. Fuchs ○ – 3; V; *05-1719*
Dryopteris cristata (L.) A. Gray – 18; S; *08-1263*
Dryopteris goldiana (Hook. ex Goldie) A. Gray ○ – 3; R; *08-862*
Dryopteris intermedia (Muhl. ex Willd.) A. Gray – 7; F; *08-1091*
Dryopteris marginalis (L.) A. Gray – 7; F; *08-705*
Polystichum acrostichoides (Michx.) Schott – 2; F; *08-1073*

Equisetaceae

Equisetum arvense L. ○ – 14; O; *09-155*
Equisetum hyemale L. ssp. *affine* (Engelm.) Calder & Roy L. Taylor ○ – 16; V; *10-19*

Lygodiaceae

Lygodium palmatum (Bernh.) Sw. ○ – 22; S; *13-157*

Onocleaceae

Onoclea sensibilis L. var. *sensibilis* ○ – 14; F; *05-1720*

Polypodium virginianum L. – 3; U; *FSE-CVS*

Ophioglossaceae

Botrypus virginianus (L.) Holub – 3; O; *08-172*
Sceptridium biternatum (Savigny) Lyon – 2; S; *09-1073*
Sceptridium dissectum (Spreng.) Lyon fo. *dissectum* – 21; S; *09-1169*
Sceptridium dissectum (Spreng.) Lyon fo. *obliquum* (Muhl. in Willd.) Weakley ined. – 21; I; *09-1092*
Sceptridium oneidense (Gilbert) Holub – 17; R; *09-05*

Osmundaceae

Osmunda claytoniana L. var. *claytoniana* – 18; O; *08-693*
Osmunda regalis L. var. *spectabilis* (Willd.) A. Gray – 17; I; *08-573*
Osmundastrum cinnamomeum (L.) C. Presl – 18; O; *08-206*

Polypodiaceae

Pleopeltis polypodioides (L.) E.G. Andrews & Windham ssp. *michauxiana* (Weath.) E.G. Andrews & Windham ○ – 3; V; *10-20*
Polypodium appalachianum Haufler & Windham – 3; O; *08-05*

Pteridaceae

Adiantum pedatum L. – 3; O; *09-152*

Thelypteridaceae

Phegopteris hexagonoptera (Michx.) Fée – 3; I; *08-761*
Thelypteris noveboracensis (L.) Nieuwl. – 3; F; *08-896*
Thelypteris palustris Schott var. *pubescens* (G. Lawson) Fernald – 17; I; *08-954*
Thelypteris simulata (Davenp.) Nieuwl. – 18; V; *08-1261*

Woodsiaceae

Woodsia appalachiana T.M.C. Taylor – 10; S; *10-401*
Woodsia ilvensis (L.) R. Brown – 10; X; *L.E. Hicks 2230* [NCU, 2 August 1956]
Woodsia obtusa (Spreng.) Torr. ssp. *obtusa* – 10; F; *08-774*

ACROGYMNOSPERMAE

Cupressaceae

†*Callitropsis* ×*leylandii* (A. B. Jacks. & Dallim.) D.P. Little – 24; S; *10-01*
†*Chamaecyparis lawsoniana* (A. Murray) Parl. – 23; V; *10-06*
†*Chamaecyparis pisifera* Siebold & Zucc. – 23; V; *10-436*
†*Cunninghamia lanceolata* (Lamb.) Hook. – 24; R; *10-07*
Juniperus virginiana L. var. *virginiana* ○ – 21; I; *08-1130*
†*Juniperus horizontalis* Moench – 24; R; *10-160*
†*Platycladus orientalis* (L.) Franco – 24; I; *12-07*
Δ*Taxodium distichum* (L.) Rich. – 24; V; *08-997*
Δ*Thuja occidentalis* L. – 23; S; *10-23*

Pinaceae

†*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr. – 19; R; *05-2305*
**Abies firma* Siebold & Zucc. + – 22; V; *10-408*
Δ*Abies fraseri* (Pursh) Poir. – 19; A; *10-78*
†*Picea abies* (L.) H. Karst. – 23; S; *09-91*
†*Picea pungens* Engelm. – 24; R; *10-02*
Δ*Picea rubens* Sarg. – 23; R; *10-437*
Δ*Pinus palustris* Mill. – 24; V; *10-478*
Pinus pungens Lamb. – 10; I; *08-1330*
Pinus rigida Mill. – 8; O; *08-1361*
Pinus strobus L. – 19; F; *08-947*
Pinus virginiana Mill. ○ – 8; F; *08-1352*
Tsuga canadensis (L.) Carrière – 2; F; *08-1283*
Tsuga caroliniana Engelm. – 4; S; *09-1107*

Taxaceae
†*Taxus baccata* L. – 23; V; *10-03*

ANGIOSPERMAE—Monocotyledoneae

Acoraceae
**Acorus calamus* L. – 17; V; *09-500*

Agavaceae
Camassia scilloides (Raf.) Cory ○ – 21; V; *10-131*
Yucca flaccida Haw. ○ – 21; F; *08-381*
^*Yucca gloriosa* L. ○ – 23; V; *10-244*

Alismataceae
Sagittaria australis (J.G. Sm.) Small ○ – 18; V; *08-1269*
Sagittaria latifolia Willd. var. *pubescens* (Muhl. ex Nutt.) J.G. Sm. – 14; I; *08-557*

Amaryllidaceae
***Allium ampeloprasum* L. – 21; R; *10-386*
Allium canadense L. var. *canadense* ○ – 21; I; *09-622*
Allium tricoccum Aiton ○ – 3; I; *09-619*
***Allium vineale* L. – 21; F; *09-621*
†*Leucojum aestivum* L. – 24; V; *12-02*
**Narcissus* ×*incomparabilis* Mill. (pro sp.) ○ – 22; R; *09-59*
†*Narcissus* ×*medioluteus* Mill. (pro sp.) – 24; I; *12-08*
**Narcissus poeticus* L. ○ – 21; R; *11-58*
**Narcissus pseudonarcissus* L. ○ – 21; O; *08-07*

Araceae
Arisaema dracontium (L.) Schott – 17; U; *FSE-CVS*
Arisaema triphyllum (L.) Schott ssp. *pusillum* (Peck) Huttl. ○ – 3; R; *09-179*
Arisaema triphyllum (L.) Schott ssp. *quinatum* (Nutt.) Huttl. – 3; R; *P.D. McMillan 2668* [NCU, 23 August 1997]
Arisaema triphyllum (L.) Schott ssp. ***stewardsonii*** (Britton) Huttl. – 18; I; *08-355*
Arisaema triphyllum (L.) Schott ssp. *triphyllum* – 3; F; *09-168*
Lemna minor L. ○ – 25; V; *09-1112*
Orontium aquaticum L. – 17; V; *09-124*
Symplocarpus foetidus (L.) Salisb. ex W.P.C. Barton – 18; A; *08-192*

Asparagaceae
**Asparagus officinalis* L. ○ – 22; S; *06-182*

Colchicaceae
Uvularia grandiflora Sm. ○ – 3; O; *09-164*
Uvularia perfoliata L. – 3; I; *09-927*
Uvularia puberula Michx. var. *puberula* – 3; F; *09-116*
Uvularia sessilifolia L. ○ – 3; V; *11-18*

Commelinaceae
***Commelina communis* L. var. *communis* – 22; A; *08-658*
***Murdannia keisak* (Hassk.) Hand.-Mazz. ○ – 22; V; *10-250*
Tradescantia ohiensis Raf. – 22; V; *10-280*
Tradescantia subaspera Ker Gawl. – 3; F; *09-181*

Cyperaceae
Bulbostylis capillaris (L.) Kunth ex C.B. Clarke – 21; S; *09-741*
Carex abscondita Mack. – 3; U; *FSE-CVS*
Carex aestivaliformis Mack. ++ – 1; V; *P.D. McMillan 1866* [CLEMS, 5 August 1996]
Carex aestivalis M.A. Curtis ex A. Gray – 7; I; *08-708*
Carex aggregata Mack. – 21; I; *10-213*
Carex albicans Willd. ex Spreng. – 7; O; *09-418*
Carex albursina E. Sheld. ○ – 3; S; *09-233*
Carex allegheniensis Mack. ○ – 18; I; *08-892*
Carex amphibola Steud. – 3; F; *10-284*
Carex annectens (E.P. Bicknell) E.P. Bicknell – 18; I; *08-371*
Carex appalachica J.M. Webber & P.W. Ball ○ – 3; F; *08-177*
Carex atlantica L.H. Bailey – 17; O; *09-512*
Carex baileyi Britton – 18; S; *09-549*
Carex blanda Dewey – 3; O; *08-372*
Carex brevior (Dewey) Lunnell ○ – 21; V; *10-189*
Carex bromoides Willd. ssp. *montana* Naczi ○ – 16; R; *11-60*
Carex brunnescens (Pers.) Poir. var. *sphaerostachya* (Tuck.) Kük. – 1; V; *10-195*
Carex bullata Schkuhr ex Willd. – 18; I; *09-637*
Carex buxbaumii Wahlenb. – 17; R; *09-499*
Carex canescens L. var. *canescens* ○ – 25; V; *10-300*
Carex cephalophora Muhl. ex Willd. – 21; F; *08-327*
Carex communis L.H. Bailey var. *communis* – 3; F; *11-20*
Carex conoidea Schkuhr ex Willd. ○ – 17; V; *09-246*
Carex crebriflora Wiegand – 3; U; *FSE-CVS*
Carex crinita Lam. var. *crinita* ○ – 18; R; *09-255*
Carex debilis Michx. – 7; F; *10-220*
Carex digitalis Willd. var. *digitalis* – 7; I; *10-155*
Carex echinata Murray ssp. *echinata* – 17; S; *09-216*
Carex flexuosa Muhl. ex Willd. ○ – 17; R; *08-554*
Carex folliculata L. – 18; I; *08-102*
Carex frankii Kunth ○ – 21; R; *11-122*
Carex glaucodea Tuck. ex Olney ○ – 6; V; *10-202*
Carex gracillima Schwein. – 3; I; *09-235*
Carex gracillima Schwein. x *C. virescens* Muhl. ex Willd. [tentative] ○ – 2; R; *09-336*
**Carex gravida* L.H. Bailey ○ – 22; R; *10-192*
Carex gynandra Schwein. – 18; F; *08-510*
Carex hirsutella Mack. ○ – 21; O; *10-341*
Carex intumescens Rudge var. *intumescens* – 18; F; *08-166*
Carex laevivaginata (Kük.) Mack. – 18; R; *09-376*
Carex laxiculmis Schwein. var. *copulata* (L.H. Bailey) Fernald ○ – 3; I; *09-394*
Carex laxiculmis Schwein. var. *laxiculmis* ○ – 3; R; *10-176*
Carex laxiflora Lam. – 3; F; *08-274*
Carex leptalea Wahlenb. var. *harperi* (Fernald) Weath. & Griscom ○ – 17; I; *10-336*
Carex leptalea Wahlenb. var. *leptalea* – 17; R; *09-474*
Carex leptonervia (Fernald) Fernald – 3; V; *09-245*
Carex longii Mack. ○ – 18; I; *09-475*
Carex lupulina Muhl. ex Willd. ○ – 14; R; *10-405*
Carex lurida Wahlenb. – 21; F; *08-364*
Carex mesochorea Mack. ○ – 21; S; *10-175*
Carex misera Buckley – 11; U; *FSE-CVS*
Carex molestiformis Reznicek & P. Rothr. + – 21; V; *10-340*
Carex muehlenbergii Schkuhr ex Willd. var. *enervis* W. Boott – 2; R; *10-249*
Carex nigromarginata Schwein. – 2; S; *10-38*
Carex normalis Mack. – 21; O; *09-684*
Carex oligocarpa Schkuhr ex Willd. ○ – 3; V; *11-74*
Carex pensylvanica Lam. – 7; F; *08-150*
Carex plantaginea Lam. – 3; S; *10-90*
Carex platyphylla J. Carey ○ – 3; R; *09-352*
Carex prasina Wahlenb. – 16; I; *09-229*
Carex radiata (Wahlenb.) Small – 21; R; *09-420*
Carex retroflexa Muhl. ex Willd. ○ – 2; R; *10-219*
Carex reznicekii Werier ○ – 21; S; *10-39*
Carex rosea Schkuhr ex Willd. – 3; O; *08-351*
Carex rugosperma Mack. ○ – 10; V; *09-450*
Carex ruthii Mack. ○ – 18; V; *09-607*
Carex scabrata Schwein. ○ – 16; S; *09-613*
Carex scoparia Schkuhr ex Willd. var. *scoparia* – 18; F; *09-600*
Carex sp. nov. – 10; S; *09-207*
Carex sparganioides Muhl. ex Willd. – 21; V; *09-569*
Carex stipata Muhl. ex Willd. var. *maxima* Chapm. ○ – 18; V; *09-375*

Carex stipata Muhl. ex Willd. var. *stipata* – 16; I; *09-232*
Carex striatula Michx. ○ – 3; S; *10-203*
Carex stricta Lam. – 17; A; *09-185*
Carex styloflexa Buckley – 17; I; *09-120*
Carex swanii (Fernald) Mack. – 5; F; *08-1353*
Carex texensis (L.H. Bailey) L.H. Bailey ○ – 3; I; *08-239*
Carex tonsa (Fernald) E.P. Bicknell ○ – 21; O; *10-36*
Carex torta Boott ○ – 14; R; *09-83*
Carex tribuloides Wahlenb. var. *tribuloides* ○ – 21; R; *09-614*
Carex trichocarpa Muhl. ex Willd. ○ – 21; R; *08-342*
Carex umbellata Schkuhr ex Willd. ○ – 21; O; *09-247*
Carex utriculata Boott ○ – 17; V; *P.D. McMillan 3562* [MICH, 1999]
Carex venusta Dewey – 17; U; *FSE-CVS*
Carex vesicaria L. ○ – 17; V; *P.D. McMillan 3755-b* [NC State Museum of Natural Sciences, 10 July 1999]
Carex virescens Muhl. ex Willd. – 1; O; *08-553*
Carex vulpinoidea Michx. – 21; O; *08-247*
Carex willdenowii Schkuhr ex Willd. ○ – 7; V; *09-328*
Carex woodii Dewey – 3; I; *11-72*
Cladium mariscoides (Muhl.) Torr. – 17; X; *A.E. Radford 38337* [NCU, 31 July 1958]
Cyperus bipartitus Torr. – 25; F; *08-1097*
Cyperus esculentus L. var. *leptostachyus* Boeck. ○ – 22; O; *10-465*
Cyperus flavescens L. – 14; I; *09-1041*
‡*Cyperus iria* L. ○ – 24; V; *05-1770*
Cyperus lancastriensis Porter ex A. Gray ○ – 21; R; *09-783*
Cyperus lupulinus (Spreng.) Marcks var. *lupulinus* – 21; O; *09-713*
Cyperus lupulinus (Spreng.) Marcks var. *macilentus* (Fernald) A. Haines – 21; S; *A.E. Radford 38287* [NCU, 31 July 1958]
Cyperus refractus Engelm. ex Boeckeler ○ – 21; V; *11-136*
Cyperus retrorsus Chapm. ○ – 9; S; *09-954*
Cyperus strigosus L. – 22; A; *10-455*
Dulichium arundinaceum (L.) Britton var. *arundinaceum* – 18; V; *A.E. Radford 40979* [NCU, 27 September 1958]
Eleocharis acicularis (L.) Roem. & Schult. – 25; S; *10-391*
Eleocharis obtusa (Willd.) Schult. – 22; F; *08-516*
Eleocharis palustris (L.) Roem. & Schult. ○ – 25; V; *10-392*
Eleocharis tenuis (Willd.) Schult. var. *pseudoptera* (Weath. ex Svenson) Svenson ○ – 17; R; *09-696*
Eleocharis tenuis (Willd.) Schult. var. *tenuis* – 21; F; *08-528*
Eleocharis tuberculosa (Michx.) Roem. & Schult. – 17; V; *09-882*
Eriophorum virginicum L. – 17; S; *08-1226*
Fimbristylis autumnalis (L.) Roem. & Schult. – 22; S; *09-976*
Kyllinga gracillima Miq. ○ – 25; I; *08-1285*
Kyllinga pumila Michx. – 25; I; *08-842*
Rhynchospora alba (L.) Vahl – 17; R; *08-587*
Rhynchospora capitellata (Michx.) Vahl – 22; F; *10-451*
Rhynchospora globularis (Chapm.) Small – 17; U; *FSE-CVS*
Rhynchospora gracilenta A. Gray – 17; V; *08-1228*
Rhynchospora recognita (Gale) Kral – 17; S; *09-787*
Schoenoplectus purshianus (Fernald) M.T. Strong – 25; O; *08-1284*
Schoenoplectus tabernaemontani (C.C. Gmel.) Palla ○ – 21; I; *06-197*
Scirpus atrovirens Willd. – 21; U; *FSE-RAB*
Scirpus cyperinus (L.) Kunth – 21; O; *06-194*
Scirpus expansus Fernald – 21; F; *08-509*
Scirpus georgianus R.M. Harper – 21; R; *10-379*
Scirpus hattorianus Makino ○ – 21; O; *09-800*
Scirpus polyphyllus Vahl – 21; O; *08-1271*
Scleria muehlenbergii Steud. – 17; R; *11-130*
Scleria pauciflora Muhl. ex Willd. var. *pauciflora* ○ – 9; S; *09-610*
Scleria triglomerata Michx. ○ – 17; R; *09-697*

Dioscoreaceae
***Dioscorea polystachya* Turcz. ○ – 23; R; *08-1052*
Dioscorea villosa L. – 7; F; *08-1320*

Eriocaulaceae
Eriocaulon decangulare L. var. *decangulare* – 17; R; *08-740*

Heloniadaceae
Chamaelirium luteum (L.) A. Gray ○ – 3; I; *09-224*

Hostaceae
∞*Hosta ventricosa* (Salisb.) Stearn ○ – 22; V; *11-126*

Hyacinthaceae
∞*Chionodoxa luciliae* Boiss. + – 24; V; *11-06*
∞*Hyacinthoides ×massartiana* Geerinck + – 14; V; *09-132*
**Muscari botryoides* (L.) Mill. ○ – 21; S; *10-32*
***Ornithogalum umbellatum* L. ○ – 21; S; *08-121*

Hydrocharitaceae
Elodea canadensis Michx. ○ – 13; I; *08-450*
Vallisneria americana Michx. ○ – 13; R; *08-464*

Hypoxidaceae
Hypoxis hirsuta (L.) Coville – 21; O; *09-200*

Iridaceae
∞*Crocus vernus* (L.) Hill ++ – 24; I; *12-01*
∞*Crocus tommasianus* Herbert ++ – 24; V; *10-10*
∞*Gladiolus ×gandavensis* Van Houtte ○ – 21; V; *08-819*
Iris cristata Aiton – 7; O; *08-195*
†*Iris germanica* L. – 24; S; *08-75*
†*Iris pallida* Lam. in Lam. et al. – 24; S; *08-83*
***Iris pseudacorus* L. ○ – 22; I; *10-150*
**Iris sanguinea* Hornem. ex Donn ○ – 21; I; *09-470*
Iris verna L. var. *smalliana* Fernald ex M.E. Edwards ○ – 5; I; *09-226*
Iris virginica L. var. *shrevei* (Small) E.S. Anderson ○ – 25; V; *09-463*
Sisyrinchium angustifolium Mill. – 21; F; *08-155*
Sisyrinchium atlanticum E.P. Bicknell – 17; O; *09-498*
Sisyrinchium montanum Greene var. *crebrum* Fernald – 21; U; *NCNHP*
Sisyrinchium mucronatum Michx. – 17; U; *FSE-CVS*

Juncaceae
Juncus acuminatus Michx. – 14; F; *08-456*
Juncus biflorus Elliott – 21; V; *10-339*
Juncus brevicaudatus (Engelm.) Fernald ○ – 17; S; *09-975*
Juncus bufonius L. var. *bufonius* ○ – 17; V; *09-1052*
Juncus canadensis J. Gay ex Laharpe – 17; U; *FSE-CVS*
Juncus coriaceus Mack. – 22; V; *10-441*
Juncus debilis A. Gray – 22; U; *FSE-RAB*
Juncus dichotomus Elliott – 21; S; *10-394*
Juncus effusus L. ssp. *solutus* (Fernald & Wiegand) Hämet-Ahti – 21; A; *11-212*
Juncus gymnocarpus Coville – 16; V; *09-1101*
Juncus longii Fernald ○ – 17; S; *09-811*
Juncus marginatus Rostk. – 17; F; *09-704*
Juncus pylaei Laharpe ○ – 21; R; *09-606*
Juncus secundus P. Beauv. ex Poir. – 9; V; *09-609*
Juncus subcaudatus (Engelm.) Coville & Blake – 17; F; *09-974*
Juncus tenuis Willd. – 21; F; *09-703*
Luzula acuminata Raf. var. *carolinae* (S. Watson) Fernald – 3; O; *08-158*
Luzula echinata (Small) F. J. Herm. – 3; F; *08-148*
Luzula multiflora (Ehrh.) Lej. var. *multiflora* ○ – 3; S; *08-254*

Liliaceae
Clintonia umbellulata (Michx.) Morong – 3; S; *09-668*
Erythronium americanum Ker Gawl. ssp. *americanum* – 3; S; *08-16*
Erythronium umbilicatum C.R. Parks & Hardin ssp. *umbilicatum* – 3; O; *09-10*
Lilium canadense L. var. ***editorum*** Fernald – 21; S; *09-760*
Lilium grayi S. Watson – 21; S; *09-573*
∞*Lilium lancifolium* Thunb. ○ – 22; R; *08-656*
Lilium michauxii Poir. – 8; O; *08-820*

Lilium superbum L. – 21; F; *09-791*
Medeola virginiana L. – 3; O; *09-400*
Prosartes lanuginosa (Michx.) D. Don – 3; O; *11-153*

Melanthiaceae
Amianthium muscitoxicum (Walter) A. Gray – 7; O; *03-14*
Stenanthium gramineum (Ker Gawl.) Morong var. ***robustum*** (S. Watson) Fernald – 17; S; *08-734*
Veratrum parviflorum Michx. ○ – 7; S; *08-1310*
Veratrum virginicum (L.) Aiton – 17; S; *07-622*
Veratrum viride Aiton – 16; I; *11-118*

Nartheciaceae
Aletris farinosa L. – 22; I; *08-386*

Orchidaceae
Aplectrum hyemale (Muhl. ex Willd.) Nutt. – 7; I; *09-15*
Arethusa bulbosa L. – 17; U; *NCNHP*
Calopogon tuberosus (L.) Britton, Sterns, & Poggenb. var. *tuberosus* – 17; R; *09-508*
Cleistesiopsis bifaria (Fernald) Pansarin & F. Barros ○ – 2; V; *10-330*
Corallorhiza odontorhiza (Willd.) Poir. ○ – 2; S; *08-1066*
Cypripedium acaule Aiton – 5; I; *10-190*
Galearis spectabilis (L.) Raf. – 3; I; *09-157*
Goodyera pubescens (Willd.) R. Brown – 3; F; *11-152*
Goodyera repens (L.) R. Brown ○ – 8; V; *09-1050*
Hexalectris spicata (Walter) Barnhart var. ***spicata*** – 6; V; *09-784*
Isotria verticillata (Muhl. ex Willd.) Raf. – 2; V; *J.L. Michael 736* [NCU, 25 June 1968]
Liparis ×jonesii S. Bentley ○ – 17; X; *S. Bentley s.n.* [VPI, 11 June 1995]
Liparis liliifolia (L.) Rich. ex Ker Gawl. – 7; I; *09-638*
Liparis loeselii (L.) Rich. – 25; R; *09-471*
Listera smallii Wiegand ○ – 8; R; *10-331*
Malaxis unifolia Michx. – 2; V; *J.L. Michael 1219* [NCU, 7 August 1968]
Platanthera ciliaris (L.) Lindl. – 18; R; *10-447*
Platanthera clavellata (Michx.) Luer – 17; S; *11-129*
Platanthera grandiflora (Bigelow) Lindl. – 17; U; *NCNHP*
Platanthera lacera (Michx.) G. Don – 17; S; *09-707*
Platanthera orbiculata (Pursh) Lindl. – 3; X; *H.R. Totten s.n.* [NCU, 15 August 1937]
Platanthera psycodes (L.) Lindl. – 3; R; *J.L. Michael 792* [NCU, 25 June 1968]
Pogonia ophioglossoides (L.) Ker Gawl. – 17; R; *09-507*
Spiranthes cernua (L.) Rich. – 22; O; *08-1338*
Spiranthes lacera (Raf.) Raf. var. *gracilis* (Bigelow) Luer – 21; S; *08-933*
Spiranthes lucida (H.H. Eaton) Ames – 25; V; *09-449*
Spiranthes tuberosa Raf. – 21; U; *FSE-RAB*
Spiranthes vernalis Engelm. & A. Gray – 21; R; *08-1202*
Tipularia discolor (Pursh) Nutt. – 6; O; *09-887*

Poaceae
***Agrostis capillaris* L. – 21; R; *08-904*
***Agrostis gigantea* Roth – 22; F; *08-488*
Agrostis perennans (Walter) Tuck. – 7; F; *08-1181*
**Agrostis stolonifera* L. – 14; R; *08-521*
Agrostis scabra Willd. – 21; V; *09-740*
**Alopecurus pratensis* L. ○ – 22; V; *09-192*
Andropogon elliottii Chapm. ○ – 22; S; *09-384*
Andropogon gerardii Vitman – 21; I; *08-795*
Andropogon glomeratus (Walter) Britton, Sterns, & Poggenb. var. *glomeratus* – 17; I; *08-1229*
Andropogon ternarius Michx. var. *ternarius* ○ – 21; R; *08-1249*
Andropogon virginicus L. var. *virginicus* – 21; A; *08-1196*
**Anthoxanthum aristatum* Boiss. – 21; U; *FSE-CVS*
**Anthoxanthum odoratum* L. – 22; F; *08-169*
Aristida dichotoma Michx. – 8; S; *09-1088*
Aristida purpurascens Poir. ○ – 8; S; *09-1089*
***Arrhenatherum elatius* (L.) J. Presl & C. Presl var. *elatius* – 21; F; *09-368*
***Arthraxon hispidus* (Thunb.) Makino var. *hispidus* ○ – 25; O; *09-1077*
**Avena sativa* L. ○ – 20; V; *09-544*
Avenella flexuosa (L.) Drejer – 10; I; *08-238*
Brachyelytrum erectum (Schreb. ex Spreng.) P. Beauv. ○ – 3; O; *08-1137*
**Bromus commutatus* Schrad. – 22; O; *08-360*
**Bromus hordeaceus* L. ssp. *hordeaceus* ○ – 22; R; *05-195*
***Bromus inermis* Leyss. ○ – 22; O; *09-430*
**Bromus japonicus* Thunb. ex Murray ○ – 22; F; *08-323*
Bromus latiglumis (Shear) Hitchc. – 14; R; *06-227*
Bromus nottowayanus Fernald ○ – 3; I; *08-801*
Bromus pubescens Muhl. ex Willd. – 3; U; *FSE-CVS*
***Bromus racemosus* L. – 22; V; *10-320*
**Bromus sterilis* L. ○ – 22; V; *10-136*
***Bromus tectorum* L. – 21; O; *09-147*
Calamagrostis canadensis (Michx.) P. Beauv. var. ***canadensis*** – 17; V; *09-579*
Calamagrostis coarctata Eaton – 17; I; *08-736*
Chasmanthium laxum (L.) H.O. Yates ○ – 5; V; *11-244*
Cinna arundinacea L. ○ – 18; I; *08-1094*
Coleataenia anceps (Michx.) Soreng ssp. *anceps* ○ – 21; O; *09-1123*
***Cynodon dactylon* (L.) Pers. var. *dactylon* ○ – 24; S; *08-455*
***Dactylis glomerata* L. – 21; A; *08-302*
Danthonia compressa Austin ex Peck ○ – 7; F; *09-669*
Danthonia sericea Nutt. ○ – 5; S; *09-627*
Danthonia spicata (L.) P. Beauv. ex Roem. & Schult. – 10; I; *09-894*
Deschampsia cespitosa (L.) P. Beauv. ssp. ***glauca*** (Hartm.) Hartm. ○ – 17; V; *09-589*
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *fasciculatum* (Torr.) Freckmann – 21; O; *09-700*
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *lindheimeri* (Nash) Gould & C.A. Clark – 21; V; *H.L. Blomquist 9932* [DUKE, 6 September 1937]
Dichanthelium annulum (Ashe) LeBlond ○ – 3; V; *09-570*
Dichanthelium boreale (Nash) Freckmann ○ – 17; V; *08-575*
Dichanthelium boscii (Poir.) Gould & C.A. Clark – 15; F; *09-571*
Dichanthelium clandestinum (L.) Gould – 21; A; *08-491*
Dichanthelium commutatum (Schult.) Gould var. *ashei* (T.G. Pearson ex Ashe) Mohlenbr. ○ – 7; R; *10-199*
Dichanthelium commutatum (Schult.) Gould var. *commutatum* – 7; O; *08-803*
Dichanthelium depauperatum (Muhl.) Gould ○ – 21; R; *09-490*
Dichanthelium dichotomum (L.) Gould var. *dichotomum* – 3; O; *08-781*
Dichanthelium dichotomum (L.) Gould var. *ramulosum* (Torr.) LeBlond ○ – 21; F; *10-332*
Dichanthelium latifolium (L.) Harvill – 7; I; *10-286*
Dichanthelium laxiflorum (Lam.) Gould ○ – 21; F; *09-323*
Dichanthelium lucidum (Ashe) LeBlond – 17; O; *08-1297*
Dichanthelium meridionale (Ashe) Freckmann – 9; R; *10-346*
Dichanthelium scoparium (Lam.) Gould ○ – 21; S; *09-744*
Dichanthelium sphaerocarpon (Elliott) Gould ○ – 21; R; *09-486*
Dichanthelium spretum (Schult.) Freckmann – 17; U; *NCNHP*
Dichanthelium villosissimum (Nash) Freckmann var. *villosissimum* ○ – 21; O; *08-536*
Dichanthelium yadkinense (Ashe) Mohlenbr. ○ – 14; V; *08-1082*
Digitaria ciliaris (Retz.) Koeler ○ – 21; R; *10-456*
**Digitaria ischaemum* (Schreb.) Muhl. ○ – 14; F; *08-1118*
**Digitaria sanguinalis* (L.) Scop. – 21; A; *10-449*
***Echinochloa crusgalli* (L.) P. Beauv. var. *crusgalli* – 21; F; *08-675*
Echinochloa muricata (P. Beauv.) Fernald var. *muricata* – 21; R; *08-1186*
***Eleusine indica* (L.) Gaertn. – 22; F; *08-677*

Elymus glabriflorus (Vasey) Scribn. & C.R. Ball var. *australis* (Scribn. & C.R. Ball) J.J.N. Campb. ○ – 14; R; *08-522*
Elymus hystrix L. var. *hystrix* ○ – 7; I; *09-816*
Elymus macgregorii R.E. Brooks & J.J.N. Campb. ○ – 3; S; *09-780*
****Elymus repens*** (L.) Gould ○ – 21; A; *08-1184*
Elymus riparius Wiegand – 14; R; *10-470*
Elymus villosus Muhl. ex Willd. – 3; F; *08-802*
Elymus virginicus L. var. *virginicus* – 21; U; *FSE-CVS*
Eragrostis capillaris (L.) Nees – 22; O; *09-926*
****Eragrostis cilianensis*** (All.) Vignolo ex Janch. – 22; S; *08-966*
****Eragrostis curvula*** (Schrad.) Nees ○ – 22; S; *09-782*
Eragrostis pectinacea (Michx.) Nees ex Steud. var. *pectinacea* ○ – 21; I; *09-768*
Eragrostis pilosa (L.) P. Beauv. var. *pilosa* ○ – 22; F; *10-344*
Eragrostis spectabilis (Pursh) Steud. ○ – 21; I; *05-1878*
‡Eragrostis tef* (Zuccagni) *Trotter* + – 21; V; *09-1042*
Festuca filiformis Pourr. – 21; U; *FSE-RAB*
Festuca paradoxa Desv. – 21; U; *FSE-CVS*
Festuca rubra L. ssp. *rubra* – 24; I; *08-82*
Festuca subverticillata (Pers.) E.B. Alexeev – 18; O; *08-252*
Festuca trachyphylla (Hack.) Krajina – 21; F; *09-259*
Glyceria declinata Bréb. + – 24; V; *08-243*
Glyceria laxa (Scribn.) Scribn. – 17; O; *10-375*
Glyceria melicaria (Michx.) F.T. Hubb. – 15; I; *08-490*
Glyceria striata (Lam.) Hitchc. var. *striata* – 15; O; *10-322*
****Holcus lanatus*** L. – 21; F; *08-362*
Hordeum jubatum L. ssp. *jubatum* ○ – 22; V; *10-321*
Hordeum pusillum Nutt. ○ – 22; R; *09-150*
Hordeum vulgare L. ○ – 22; R; *09-466*
Leersia oryzoides (L.) Sw. – 17; F; *08-878*
Leersia virginica Willd. – 15; F; *08-711*
Lolium perenne L. var. *aristatum* Willd. ○ – 22; F; *08-251*
Lolium perenne L. var. *perenne* ○ – 21; R; *10-343*
Melica mutica Walter ○ – 3; V; *10-135*
****Microstegium vimineum*** (Trin.) A. Camus – 22; A; *09-940*
****Miscanthus sinensis*** Andersson var. *sinensis* ○ – 22; O; *08-1324*
****Miscanthus sinensis*** Andersson var. *variegatus* Beal ○ – 22; S; *09-1116*
Muhlenbergia frondosa (Poir.) Fernald – 14; I; *09-1033*
Muhlenbergia mexicana (L.) Trin. ○ – 22; S; *08-1355*
Muhlenbergia schreberi J.F. Gmel. var. *palustris* (Scribn.) Scribn. – 21; F; *08-1308*
Muhlenbergia schreberi J.F. Gmel. var. *schreberi* – 21; F; *08-1129*
Muhlenbergia sylvatica Torr. ex A. Gray ○ – 3; V; *10-480*
Muhlenbergia tenuiflora (Willd.) Britton, Sterns, & Poggenb. ○ – 3; O; *09-1046*
Panicum capillare L. ○ – 21; I; *09-1084*
Panicum dichotomiflorum Michx. var. *dichotomiflorum* – 21; F; *10-433*
‡Panicum miliaceum* L. ssp. *miliaceum* ○ – 22; V; *10-444*
Panicum philadelphicum Bernh. ex Trin. – 17; R; *09-951*
Panicum virgatum L. var. *cubense* Griseb. ○ – 17; S; *08-534*
Panicum virgatum L. var. *virgatum* – 17; I; *08-1166*
Paspalum dilatatum Poir. ○ – 22; I; *09-779*
Paspalum floridanum Michx. ○ – 22; S; *08-1306*
Paspalum floridanum Michx. X *P. laeve* Michx. [tentative]○ – 21; V; *09-952*
Paspalum laeve Michx. var. *laeve* – 21; F; *08-930*
Paspalum pubiflorum Rupr. ex Fourn. var. *glabrum* Vasey ex Scribn. ○ – 22; R; *11-210*
Paspalum setaceum Michx. var. *muhlenbergii* (Nash) Fernald – 21; F; *09-893*
Pennisetum alopecuroides (L.) Spreng. + – 22; R; *09-1135*
‡Pennisetum glaucum* (L.) R. Brown ○ – 20; R; *08-1139*
Phalaris arundinacea L. fo. *arundinacea* – 21; A; *08-296*
Phalaris arundinacea L. fo. *variegata* (Parn.) Druce ○ – 23; R; *09-536*
****Phleum pratense*** L. ssp. *pratense* ○ – 21; F; *09-574*
****Phyllostachys aurea*** Carrière ex Rivière & C. Rivière ○ – 14; R; *07-226*
Piptochaetium avenaceum (L.) Parodi ○ – 6; S; *10-206*
Poa alsodes A. Gray ○ – 7; R; *09-459*
****Poa annua*** L. – 22; F; *09-56*
Poa autumnalis Muhl. ex Elliott – 3; U; *FSE-RAB*
****Poa compressa*** L. ○ – 21; F; *08-312*
Poa cuspidata Nutt. ○ – 3; F; *09-41*
****Poa pratensis*** L. ssp. *pratensis* – 21; A; *11-112*
****Poa trivialis*** L. ssp. *trivialis* – 21; F; *08-250*
Saccharum brevibarbe (Michx.) Pers. var. *contortum* (Elliott) R.D. Webster ○ – 21; V; *11-251*
****Schedonorus arundinaceus*** (Schreb.) Dumort. ○ – 21; A; *11-178*
Schizachyrium scoparium (Michx.) Nash var. *scoparium* – 21; F; *08-875*
Secale cereale L. ○ – 22; F; *08-809*
****Setaria faberi*** R.A.W. Herrm. ○ – 22; F; *08-678*
****Setaria italica*** (L.) P. Beauv. ○ – 22; R; *10-432*
Setaria parviflora (Poir.) Kerguélen – 21; F; *08-757*
****Setaria pumila*** (Poir.) Roem. & Schult. ssp. *pumila* – 21; F; *09-979*
****Setaria viridis*** (L.) P. Beauv. var. *major* (Gaudin) Posp. + – 22; R; *09-1037*
****Setaria viridis*** (L.) P. Beauv. var. *viridis* ○ – 22; F; *09-1094*
Sorghastrum nutans (L.) Nash – 21; F; *08-756*
Sorghum bicolor (L.) Moench var. *bicolor* ○ – 22; R; *09-973*
****Sorghum halepense*** (L.) Pers. ○ – 22; F; *08-854*
Spartina pectinata Link – 21; S; *08-1305*
Sphenopholis intermedia (Rydb.) Rydb. ○ – 3; R; *08-257*
Sphenopholis nitida (Biehler) Scribn. – 3; O; *09-227*
Sphenopholis pensylvanica (L.) Hitchc. – 17; O; *09-415*
Sporobolus indicus (L.) R. Brown ○ – 22; S; *08-535*
Sporobolus vaginiflorus (Torr. ex A. Gray) Alph. Wood ○ – 22; I; *08-1233*
Tridens flavus (L.) Hitchc. – 21; F; *08-936*
Tripsacum dactyloides (L.) L. var. *dactyloides* ○ – 22; S; *09-919*
Triticum aestivum L. ○ – 20; O; *08-324*
Urochloa ramosa (L.) T.Q. Nguyen ○ – 22; R; *08-1116*
Vulpia myuros (L.) C. C. Gmel. ○ – 22; S; *09-629*
Vulpia octoflora (Walter) Rydb. var. *octoflora* ○ – 9; S; *09-631*
‡Zea mays* L. ssp. *mays* ○ – 20; S; *08-1000*

Pontederiaceae

Heteranthera dubia (Jacq.) MacMill. – 14; V; *A.E. Radford 44195* [NCU, 1 August 1961]

Potamogetonaceae

Potamogeton diversifolius Raf. – 25; S; *08-1287*
Potamogeton epihydrus Raf. – 13; V; *09-826*
Potamogeton foliosus Raf. var. *foliosus* – 13; V; *S.W. Leonard 2075* [NCU, 20 September 1968]

Ruscaceae

Convallaria majalis L. ○ – 23; V; *10-99*
Convallaria majuscula Greene ○ – 5; I; *09-338*
****Liriope muscari*** (Decne.) L.H. Bailey ○ – 23; S; *10-438*
Maianthemum canadense Desf. – 1; F; *10-191*
Maianthemum racemosum (L.) Link ssp. *racemosum* – 3; F; *08-479*
Polygonatum biflorum (Walter) Elliott var. *biflorum* – 3; O; *08-512*
Polygonatum biflorum (Walter) Elliott var. *commutatum* (Schultes & Schultes f.) Morong – 3; I; *09-439*
Polygonatum pubescens (Willd.) Pursh – 3; S; *11-16*

Smilacaceae

Smilax bona-nox L. – 17; U; *FSE-CVS*
Smilax glauca Walter – 21; F; *09-526*
Smilax herbacea L. – 21; F; *09-407*
Smilax hispida Raf. – 15; I; *09-992*

Smilax rotundifolia L. – 22; F; *09-529*

Trilliaceae

Trillium erectum L. – 3; U; *FSE-RAB*
Trillium sulcatum T.S. Patrick fo. *albolutescens* T.S. Patrick ○ – 3; R; *10-83*
Trillium sulcatum T.S. Patrick fo. *sulcatum* – 3; O; *08-96*
Trillium undulatum Willd. – 2; R; *09-110*

Typhaceae

Sparganium americanum Nutt. – 14; I; *08-1301*
Typha latifolia L. ○ – 16; I; *08-1250*

Xanthorrhoeaceae

***Hemerocallis fulva* (L.) L. ○ – 22; O; *08-1001*
†*Hemerocallis lilioasphodelus* L. – 23; V; *10-318*
†*Kniphofia uvaria* (L.) Oken – 22; V; *10-233*

Xyridaceae

Xyris torta Sm. in Rees – 17; R; *09-814*

ANGIOSPERMAE—Nymphaeales

Nymphaeaceae

Nuphar advena (Aiton) R. Brown ex W.T. Aiton ○ – 25; V; *10-292*
Nymphaea odorata W.T. Aiton ssp. *odorata* ○ – 25; V; *10-293*

ANGIOSPERMAE—Magnoliidae

Aristolochiaceae

Asarum canadense L. – 3; I; *09-154*
Endodeca serpentaria (L.) Raf. – 5; R; *09-1141*
Hexastylis virginica (L.) Small – 7; I; *08-104*
Isotrema macrophyllum (Lam.) C.F. Reed – 3; I; *11-73*

Calycanthaceae

Calycanthus floridus L. var. *glaucus* (Willd.) Torr. & A. Gray ○ – 23; V; *10-145*

Lauraceae

Lindera benzoin (L.) Blume – 3; F; *09-395*
Sassafras albidum (Nutt.) Nees – 21; O; *08-1136*

Magnoliaceae

Liriodendron tulipifera L. var. *tulipifera* – 3; A; *08-226*
Magnolia acuminata (L.) L. var. *acuminata* – 7; F; *08-1294*
Magnolia fraseri Walter – 7; F; *09-260*
Δ*Magnolia grandiflora* L. – 24; S; *08-1289*
†*Magnolia ×soulangiana* Soul.-Bod. – 24; V; *10-435*
Magnolia tripetala (L.) L. ○ – 18; S; *08-1303*

ANGIOSPERMAE—Eudicotyledoneae

Adoxaceae

Sambucus canadensis L. – 22; F; *08-1108*
Viburnum acerifolium L. – 5; O; *08-1069*
Viburnum cassinoides L. – 17; O; *09-423*
□*Viburnum dilatatum* Thunb. ++ – 24; V; *11-246*
Viburnum nudum L. – 18; S; *09-198*
†*Viburnum opulus* L. var. *opulus* – 23; S; *10-146*
∞*Viburnum plicatum* Thunb. ○ – 24; V; *11-247*
Viburnum prunifolium L. ○ – 15; O; *09-109*
∞*Viburnum rhytidophyllum* Hemsl. ○ – 23; V; *10-82*

Altingiaceae

^*Liquidambar styraciflua* L. ○ – 24; V; *09-928*

Amaranthaceae

**Amaranthus albus* L. ○ – 20; R; *08-813*
**Amaranthus hybridus* L. – 22; I; *08-812*
**Amaranthus palmeri* S. Watson ○ – 22; V; *10-468*
**Amaranthus retroflexus* L. ○ – 20; V; *08-814*
**Amaranthus spinosus* L. ○ – 20; S; *08-1126*
‡*Celosia argentea* L. ○ – 22; V; *11-142*
Chenopodium album L. – 21; F; *08-1024*
Chenopodium simplex (Torr.) Raf. ○ – 11; S; *08-699*
***Dysphania ambrosioides* (L.) Mosyakin & Clemants – 22; S; *05-1716*

Anacardiaceae

Rhus copallinum L. var. *latifolia* Engl. – 22; F; *08-822*
Rhus glabra L. – 22; F; *08-823*
Rhus typhina L. – 22; S; *08-972*
Toxicodendron radicans (L.) Kuntze var. *radicans* – 22; F; *11-194*
Toxicodendron vernix (L.) Kuntze – 18; S; *08-1165*

Apiaceae

**Aegopodium podagraria* L. ○ – 22; I; *09-429*
Angelica triquinata Michx. ○ – 3; R; *09-968*
Angelica venenosa (Greenway) Fernald – 21; I; *09-761*
Angelica atropurpurea L. – 21; U; *NCNHP*
**Anthriscus sylvestris* (L.) Hoffm. ssp. *sylvestris* + – 22; V; *08-217*
Cicuta maculata L. var. *maculata* – 17; O; *08-1290*
***Conium maculatum* L. – 20; I; *08-321*
Cryptotaenia canadensis (L.) DC. – 3; O; *08-356*
***Daucus carota* L. – 21; A; *08-668*
Eryngium integrifolium Walter – 17; V; *A.E. Radford 41022* [NCU, 27 September 1958]
Heracleum maximum W. Bartram ○ – 15; S; *09-416*
Ligusticum canadense (L.) Britton – 3; S; *09-656*
Osmorhiza claytonii (Michx.) C.B. Clarke – 3; F; *09-386*
Osmorhiza longistylis (Torr.) DC. – 3; O; *09-146*
Oxypolis rigidior (L.) Raf. – 17; O; *08-797*
***Pastinaca sativa* L. – 22; S; *09-764*
‡*Petroselinum crispum* (Mill.) Nyman ex A.W. Hill ○ – 24; V; *11-149*
Sanicula canadensis L. var. *canadensis* – 2; F; *08-714*
Sanicula odorata (Raf.) Pryer & Phillippe ○ – 3; R; *09-393*
Sanicula trifoliata E.P. Bicknell – 3; S; *09-618*
Thaspium barbinode (Michx.) Nutt. ○ – 3; O; *09-411*
Thaspium trifoliatum (L.) A. Gray var. *aureum* (L.) Britton ○ – 3; F; *09-414*
Zizia aptera (A. Gray) Fernald ○ – 22; I; *10-237*
Zizia aurea (L.) W.D.J. Koch – 22; F; *09-421*
Zizia trifoliata (Michx.) Fernald – 7; O; *09-350*

Apocynaceae

Apocynum androsaemifolium L. – 21; S; *10-371*
Apocynum cannabinum L. – 21; F; *10-369*
Apocynum ×floribundum Greene (pro sp.) ○ – 21; V; *10-370*
Asclepias exaltata L. ○ – 7; I; *09-624*
Asclepias incarnata L. var. *pulchra* (Ehrh. ex Willd.) Pers. – 21; I; *08-571*
Asclepias quadrifolia Jacq. – 3; V; *10-236*
Asclepias syriaca L. – 21; F; *08-729*
Asclepias tuberosa L. var. *tuberosa* – 21; F; *09-751*
***Vinca major* L. ○ – 24; V; *10-222*
***Vinca minor* L. ○ – 22; F; *09-01*

Aquifoliaceae

Ilex ambigua (Michx.) Torr. – 7; U; *NCNHP*
†*Ilex cornuta* Lindl. – 23; V; *10-424*
∞*Ilex crenata* Thunb. ○ – 23; S; *10-18*
Ilex montana Torr. & A. Gray ex A. Gray – 7; F; *08-869*
Ilex opaca Aiton var. *opaca* – 7; F; *08-895*
Ilex verticillata (L.) A. Gray – 18; F; *08-1265*

Araliaceae

Aralia nudicaulis L. – 1; F; *08-193*
Aralia racemosa L. – 2; S; *10-390*
Aralia spinosa L. ○ – 21; S; *08-1329*

**Hedera helix* L. var. *helix* ○ – 23; S; *08-1281*
Hydrocotyle americana L. ○ – 16; S; *09-580*
**Hydrocotyle sibthorpioides* Lam. ○ – 24; R; *10-461*
Panax quinquefolius L. ○ – 3; S; *08-759*

Asteraceae

Achillea millefolium L. – 21; F; *09-158*
Ageratina altissima R.M. King & H. Rob. var. *altissima* – 5; I; *10-418*
Ageratina altissima R.M. King & H. Rob. var. *roanensis* (Small) Clewell & Wooten – 7; O; *08-689*
Ambrosia artemisiifolia L. – 21; A; *11-193*
Ambrosia trifida L. var. *trifida* – 21; F; *11-167*
Antennaria howellii Greene ssp. *neodioica* (Greene) R.J. Bayer ○ – 10; V; *09-447*
Antennaria parlinii Fernald ssp. *fallax* (Greene) R.J. Bayer & Stebbins ○ – 21; O; *11-59*
Antennaria parlinii Fernald ssp. *parlinii* ○ – 21; I; *09-63*
Antennaria plantaginifolia (L.) Richardson – 21; O; *09-98*
Antennaria solitaria Rydb. ○ – 2; V; *11-04*
**Anthemis arvensis* L. – 22; I; *09-378*
**Arctium lappa* L. ○ – 21; V; *09-1068*
***Arctium minus* Bernh. – 21; F; *08-670*
Arnoglossum atriplicifolium (L.) H. Rob. – 7; O; *08-1017*
∞*Artemisia ludoviciana* Nutt. ○ – 23; V; *10-453*
***Artemisia vulgaris* L. ○ – 21; F; *08-994*
**Aster tataricus* L. f. ○ – 23; R; *08-1365*
Bidens aristosa (Michx.) Britton ○ – 22; V; *09-1047*
Bidens bipinnata L. – 21; F; *08-1198*
Bidens cernua L. – 14; R; *09-1146*
Bidens connata Muhl. – 18; R; *09-1147*
Bidens frondosa L. – 21; F; *08-1304*
**Bidens polylepis* Blake – 22; O; *10-477*
Bidens vulgata Greene ○ – 22; I; *08-1009*
Brickellia eupatorioides (L.) Shinners var. *eupatorioides* – 22; X; *R.K. Godfrey 50214* [NCSC, 6 September 1949]
***Carduus acanthoides* L. ssp. *acanthoides* ○ – 21; I; *08-672*
***Carduus nutans* L. ssp. *macrolepis* (Peterm.) Kazmi ○ – 21; R; *09-825*
***Centaurea cyanus* L. ○ – 20; R; *11-68*
***Centaurea jacea* L. + – 22; S; *08-965*
**Centaurea ×moncktonii* C.E. Britton + – 21; I; *09-1002*
**Centaurea nigrescens* Willd. + – 22; V; *09-1007*
***Centaurea stoebe* L. ssp. *micranthos* (S.G. Gmel. ex Gugler) Hayek – 21; F; *09-1006*
Chrysopsis mariana (L.) Elliott – 21; O; *08-893*
***Cichorium intybus* L. – 21; F; *08-487*
***Cirsium arvense* (L.) Scop. var. *arvense* ○ – 21; R; *08-853*
***Cirsium arvense* (L.) Scop. var. *horridum* Wimm. & Grab. ○ – 21; O; *09-743*
Cirsium discolor (Muhl. ex Willd.) Spreng. – 21; F; *11-200*
***Cirsium vulgare* (Savi) Ten. – 21; F; *08-942*
Conoclinium coelestinum (L.) DC. ○ – 22; S; *08-1247*
Conyza canadensis (L.) Cronquist var. *canadensis* – 21; F; *08-1113*
Conyza canadensis (L.) Cronquist var. *pusilla* (Nutt.) Cronquist – 21; S; *10-426*
ΔCoreopsis *lanceolata* L. aff. var. *lanceolata* – 22; V; *09-1114*
‡Coreopsis *lanceolata* L. aff. var. *villosa* Michx. ○ – 22; V; *10-275*
Coreopsis major Walter var. *rigida* (Nutt.) F.E. Boynton – 5; F; *08-563*
Coreopsis pubescens Elliott var. *pubescens* – 7; F; *10-319*
Coreopsis pubescens Elliott var. *robusta* A. Gray ex Eames – 7; S; *A.E. Radford 44946* [NCU, 12 July 1966]
**Cosmos bipinnatus* Cav. ○ – 22; S; *09-1127*
**Crepis capillaris* (L.) Wallr. – 21; F; *08-700*
Doellingeria umbellata (Mill.) Nees – 17; O; *08-1173*
^***Echinacea purpurea*** (L.) Moench ○ – 21; V; *09-774*
Eclipta prostrata (L.) L. ○ – 24; V; *12-88*
Elephantopus carolinianus Raeusch. – 7; R; *06-247*
Elephantopus tomentosus L. – 2; S; *09-966*
Erechtites hieraciifolius (L.) Raf. ex DC. – 21; F; *11-196*
Erigeron annuus (L.) Pers. – 21; F; *08-318*
Erigeron philadelphicus L. var. *philadelphicus* – 21; O; *08-100*
Erigeron pulchellus Michx. var. *pulchellus* – 3; O; *08-113*
Erigeron strigosus Muhl. ex Willd. var. nov.? [sexual diploid]○ – 12; R; *09-612*
Erigeron strigosus Muhl. ex Willd. var. *strigosus* [polyploid apomict]– 21; F; *08-352*
Eupatorium album L. var. *album* ○ – 21; S; *09-925*
Eupatorium capillifolium (Lam.) Small ○ – 21; R; *11-245*
Eupatorium hyssopifolium L. ○ – 21; R; *08-1248*
Eupatorium perfoliatum L. – 21; F; *08-955*
Eupatorium pilosum Walter – 17; S; *09-964*
Eupatorium pubescens Muhl. ex Willd. ○ – 17; I; *08-1246*
Eupatorium rotundifolium L. ○ – 21; V; *09-963*
Eupatorium serotinum Michx. ○ – 21; V; *11-156*
Eupatorium sessilifolium L. var. *sessilifolium* – 7; O; *05-1746A*
Eurybia chlorolepis (E.S. Burgess) G.L. *Nesom* – 3; I; *09-890*
Eurybia divaricata (L.) G.L. Nesom – 7; F; *08-1018*
Eurybia macrophylla (L.) Cass. ○ – 3; R; *09-935*
Euthamia graminifolia (L.) Nutt. var. *nuttallii* (Greene) W. Stone ○ – 21; S; *09-980*
Eutrochium fistulosum (Barratt) E.E. Lamont – 21; F; *09-1164*
Eutrochium purpureum (L.) E.E. Lamont var. *purpureum* – 3; I; *09-1012*
Eutrochium steelei (E.E. Lamont) E.E. Lamont ○ – 3; R; *09-1162*
**Galinsoga quadriradiata* Ruiz & Pav. – 22; F; *08-380*
Gamochaeta argyrinea G.L. Nesom ○ – 24; V; *12-87*
**Gamochaeta pensylvanica* (Willd.) Cabrera ○ – 22; I; *08-1349*
Gamochaeta purpurea (L.) Cabrera ○ – 21; S; *08-143*
Helenium autumnale L. – 21; F; *08-748*
Helenium brevifolium (Nutt.) Alph. Wood – 17; V; *11-108*
Helenium flexuosum Raf. – 21; O; *08-1258*
**Helianthus annuus* L. ○ – 22; R; *09-962*
Helianthus atrorubens L. – 22; R; *09-1003*
Helianthus decapetalus L. – 7; R; *09-988*
Helianthus divaricatus L. – 10; S; *09-913*
Helianthus giganteus L. – 21; F; *08-1101*
**Helianthus maximilianii* Schrad. ○ – 21; V; *09-1034*
Helianthus microcephalus Torr. & A. Gray – 7; F; *08-1104*
Helianthus strumosus L. ○ – 22; O; *08-1100*
**Helianthus tuberosus* L. ○ – 22; S; *08-985*
Heliopsis helianthoides (L.) Sweet var. *helianthoides* – 3; I; *08-666*
**Hieracium caespitosum* Dumort. – 21; F; *08-293*
Hieracium gronovii L. – 21; O; *09-829*
Hieracium paniculatum L. – 7; O; *08-1027*
**Hieracium pilosella* L. – 22; I; *08-122*
Hieracium scabrum Michx. – 22; S; *09-923*
Hieracium venosum L. – 7; F; *09-370*
**Hypochaeris radicata* L. ○ – 21; A; *08-125*
Ionactis linariifolia (L.) Greene – 10; R; *09-1029*
Krigia virginica (L.) Willd. – 22; I; *09-88*
Lactuca biennis (Moench) Fernald ○ – 21; F; *11-170*
Lactuca canadensis L. – 22; O; *08-980*
Lactuca floridana (L.) Gaertn. ○ – 22; R; *09-1133*
**Lactuca serriola* L. – 22; F; *08-1185*
***Lapsana communis* L. ○ – 21; R; *05-765*
***Leucanthemum vulgare* Lam. – 21; F; *09-575*
Liatris spicata (L.) Willd. var. *resinosa* (Nutt.) Gaiser – 17; V; *08-548*
Liatris spicata (L.) Willd. var. *spicata* – 21; R; *09-802*
**Matricaria discoidea* DC. ○ – 21; F; *08-306*
Oclemena acuminata (Michx.) Greene ○ – 8; R; *08-1332*
Packera anonyma (Alph. Wood) W.A. Weber & Á. Löve – 21; F; *09-584*

Packera aurea (L.) Á. Löve & D. Löve – 3; A; *08-127*
Packera obovata (Muhl. ex Willd.) W.A. Weber & Á. Löve – 3; U; *FSE-CVS*
Pityopsis aspera (Shuttlew. ex Small) Small var. *adenolepis* (Fernald) Semple & Bowers – 22; R; *09-982*
Prenanthes alba L. ○ – 3; V; *11-155*
Prenanthes altissima L. ○ – 3; F; *08-1351*
Prenanthes roanensis (Chick.) Chick. – 7; R; *09-1121*
Prenanthes serpentaria Pursh – 7; R; *09-1122*
Prenanthes trifoliolata (Cass.) Fernald – 7; S; *09-1117*
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt – 21; F; *08-1195*
Pyrrhopappus carolinianus (Walter) DC. ○ – 22; V; *09-918*
Rudbeckia fulgida Aiton var. *fulgida* ○ – 22; R; *09-1151*
‡*Rudbeckia hirta* L. cv. 'Gloriosa Daisy' ○ – 22; V; *08-1002*
Rudbeckia hirta L. var. *pulcherrima* Farw. – 22; F; *09-1048*
Rudbeckia laciniata L. var. *laciniata* – 21; F; *11-162*
Rudbeckia triloba L. var. *triloba* ○ – 23; R; *09-1145*
**Senecio vulgaris* L. ○ – 20; F; *08-815*
Sericocarpus asteroides (L.) Britton, Sterns, & Poggenb. – 7; S; *10-381*
Sericocarpus linifolius (L.) Britton, Sterns, & Poggenb. – 5; R; *10-349*
Silphium connatum L. – 21; S; *09-564*
Silphium perfoliatum L. – 21; S; *09-545*
Silphium reniforme Raf. ex Nutt. – 7; R; *09-1134*
Smallanthus uvedalius (L.) Mack. ex Small ○ – 22; S; *08-973*
Solidago altissima L. var. *altissima* – 21; F; *08-1307*
Solidago arguta Aiton var. *caroliniana* A. Gray – 22; F; *09-1126*
Solidago bicolor L. – 22; O; *08-1106*
Solidago canadensis L. var. *hargeri* Fernald ○ – 21; S; *09-1035*
Solidago curtisii Torr. & A. Gray – 3; F; *08-1120*
Solidago erecta Pursh – 22; S; *09-1140*
Solidago flexicaulis L. – 3; R; *09-1139*
Solidago gigantea Aiton – 21; F; *11-169*
Solidago juncea Aiton – 21; F; *08-912*
Solidago nemoralis Aiton var. *nemoralis* – 21; F; *08-968*
Solidago odora Aiton – 22; V; *09-1124*
Solidago patula Muhl. ex Willd. var. *patula* – 17; O; *08-960*
Solidago pinetorum Small – 21; I; *08-906*
Solidago puberula Nutt. var. *puberula* – 22; I; *09-1119*
Solidago roanensis Porter – 1; O; *08-934*
Solidago rugosa Mill. var. *aspera* (Aiton) Fernald – 21; F; *08-1187*
**Sonchus arvensis* L. var. *glabrescens* (Günther) Grab. & Wimm. ○ – 22; R; *08-824*
**Sonchus asper* (L.) Hill ○ – 21; F; *08-836*
**Sonchus oleraceus* L. ○ – 22; O; *08-1350*
Symphyotrichum cordifolium (L.) G.L. Nesom – 3; F; *09-1132*
Symphyotrichum dumosum (L.) G.L. Nesom var. *dumosum* – 21; O; *11-254*
Symphyotrichum lanceolatum (Willd.) G.L. Nesom var. *lanceolatum* ○ – 22; S; *09-1175*
Symphyotrichum lateriflorum (L.) Á. Löve & D. Löve var. *lateriflorum* – 22; F; *08-1259*
Symphyotrichum novae-angliae (L.) G.L. Nesom ○ – 22; S; *08-1288*
Symphyotrichum aff. *novi-belgii* (L.) G.L. Nesom [sp. or var. nov.?] ○ – 17; R; *11-259*
Symphyotrichum patens (Aiton) G.L. Nesom var. *patens* ○ – 3; I; *09-1176*
Symphyotrichum pilosum (Willd.) G.L. Nesom var. *pilosum* – 21; F; *08-941*
Symphyotrichum prenanthoides (Muhl. ex Willd.) G.L. Nesom ○ – 3; O; *09-1063*
Symphyotrichum puniceum (L.) Á. Löve & D. Löve var. *puniceum* – 21; F; *08-1211*
Symphyotrichum sp. [subsect. *Dumosi*] ○ – 21; V; *11-253*
Symphyotrichum aff. *undulatum* (L.) G.L. Nesom [sp. or var. nov.?] ○ – 22; V; *09-981*
Symphyotrichum undulatum (L.) G.L. Nesom – 22; F; *08-1205*
‡*Tagetes erecta* L. ○ – 22; R; *11-135*
‡*Tagetes patula* L. ○ – 23; V; *08-669*
**Tanacetum parthenium* (L.) Sch. Bip. ○ – 22; V; *10-355*
**Tanacetum vulgare* L. – 22; R; *10-473*
**Taraxacum erythrospermum* Andrz. ex Besser ○ – 21; R; *08-261*
**Taraxacum officinale* Weber ex F.H. Wigg. – 21; A; *08-288*
***Tragopogon dubius* Scop. ○ – 21; S; *09-452*
***Tussilago farfara* L. – 22; F; *09-09*
Verbesina alternifolia (L.) Britton ex Kearney – 21; F; *11-175*
Verbesina occidentalis (L.) Walter – 21; O; *08-925*
Vernonia noveboracensis (L.) Michx. – 21; F; *08-1286*
Xanthium strumarium L. – 21; S; *11-225*

Balsaminaceae

‡*Impatiens balsamina* L. ○ – 22; V; *11-243*
Impatiens capensis Meerb. – 15; A; *11-172*
Impatiens pallida Nutt. – 15; A; *08-1053*
‡*Impatiens walleriana* Hook. f. ○ – 24; V; *11-241*

Berberidaceae

***Berberis bealei* Fortune ○ – 23; S; *10-04*
***Berberis thunbergii* DC. ○ – 21; F; *09-61*
Caulophyllum giganteum (Farw.) Loconte & W.H. Blackwell – 3; R; *08-13*
Caulophyllum thalictroides (L.) Michx. – 3; O; *08-93*
***Nandina domestica* Thunb. ○ – 23; R; *10-242*
Podophyllum peltatum L. – 3; F; *08-97*

Betulaceae

Alnus serrulata (Aiton) Willd. – 14; F; *08-292*
Betula alleghaniensis Britton – 15; O; *08-1093*
Betula lenta L. var. *lenta* – 3; F; *08-775*
Betula nigra L. ○ – 16; V; *10-256*
**Betula pendula* Roth + – 21; R; *09-504*
Carpinus caroliniana Walter var. *virginiana* (Marshall) Fernald ○ – 15; I; *08-299*
Corylus americana Walter – 3; O; *08-1363*
Corylus cornuta Marshall var. *cornuta* – 5; I; *08-1075*
Ostrya virginiana (Mill.) K. Koch – 7; O; *09-354*

Bignoniaceae

Campsis radicans (L.) Seem. ex Bureau ○ – 22; S; *08-852*
^*Catalpa speciosa* (Warder) Warder ex Engelm. ○ – 22; S; *10-310*

Boraginaceae

***Buglossoides arvensis* (L.) I.M. Johnst. ssp. *arvensis* – 21; V; *11-17*
Cynoglossum virginianum L. var. *virginianum* ○ – 7; I; *09-335*
**Echium vulgare* L. – 22; R; *09-657*
Hackelia virginiana (L.) I.M. Johnst. – 3; I; *08-683*
Hydrophyllum canadense L. – 3; I; *09-617*
Hydrophyllum virginianum L. var. *atranthum* (Alexander) Constance – 3; O; *08-95*
**Myosotis scorpioides* L. – 14; A; *08-520*
**Myosotis sylvatica* Ehrh. ex Hoffm. ○ – 24; V; *11-56*
Phacelia dubia (L.) Trel. var. *dubia* – 22; I; *08-298*
Phacelia fimbriata Michx. ○ – 21; R; *08-242*

Brassicaceae

***Alliaria petiolata* (M. Bieb.) Cavara & Grande – 21; F; *08-317*
Arabidopsis lyrata (L.) O'Kane & Al-Shehbaz ssp. *lyrata* – 15; V; *09-151*
**Arabidopsis thaliana* (L.) Heynh. ○ – 21; S; *08-70*
**Barbarea verna* (Mill.) Asch. – 21; I; *09-24*
***Barbarea vulgaris* R. Brown – 21; F; *09-29*
Boechera canadensis (L.) Al-Shehbaz – 3; I; *09-555*
Boechera laevigata (Muhl. ex Willd.) Al-Shehbaz – 3; O; *09-39*
**Brassica juncea* (L.) Czern. ○ – 22; V; *09-654*

‡*Brassica napus* L. ○ – 20; V; *08-205*
**Brassica rapa* L. var. *rapa* ○ – 21; F; *09-42*
**Capsella bursa-pastoris* (L.) Medik. – 21; F; *08-110*
Cardamine bulbosa (Schreb. ex Muhl.) Britton, Sterns, & Poggenb. ○ – 16; R; *09-108*
Cardamine concatenata (Michx.) O. Schwarz – 3; F; *09-171*
Cardamine diphylla (Michx.) Alph. Wood – 3; U; *A.E. Radford 32742* [NCU, 2 May 1958]
Cardamine flagellifera O.E. Schulz var. *flagellifera* – 16; I; *10-86*
**Cardamine flexuosa* With. ○ – 21; R; *10-33*
**Cardamine hirsuta* L. – 22; F; *09-23*
**Cardamine impatiens* L. – 21; I; *07-145*
Cardamine parviflora L. var. *arenicola* (Britton) O.E. Schulz – 14; R; *10-96*
Cardamine pensylvanica Muhl. ex Willd. – 16; I; *10-156*
Cardamine rotundifolia Michx. ○ – 16; R; *10-159*
**Draba verna* L. – 22; O; *08-06*
***Hesperis matronalis* L. ○ – 21; I; *08-353*
†*Iberis sempervirens* L. – 24; V; *12-46*
**Lepidium campestre* (L.) R. Brown – 21; I; *08-114*
Lepidium virginicum L. var. *virginicum* – 22; F; *09-136*
‡*Lobularia maritima* (L.) Desv. ○ – 24; V; *11-146*
**Lunaria annua* L. ○ – 22; I; *09-40*
***Microthlaspi perfoliatum* (L.) F.K. Mey. ○ – 22; V; *10-165*
***Nasturtium officinale* R. Brown ○ – 24; S; *10-311*
Planodes virginicum (L.) Greene ○ – 22; V; *10-45*
***Raphanus raphanistrum* L. ○ – 21; S; *08-1031*
**Raphanus sativus* L. ○ – 20; R; *12-12*
**Rorippa palustris* (L.) Besser ssp. *palustris* – 14; S; *08-458*
**Sisymbrium officinale* (L.) Scop. – 20; O; *08-322*
**Thlaspi alliaceum* L. ○ – 22; V; *12-15*
**Thlaspi arvense* L. – 20; O; *08-154*

Buxaceae
†*Buxus sempervirens* L. – 23; I; *10-09*
∞*Pachysandra terminalis* Siebold & Zuccarini ○ – 24; S; *10-84*

Cactaceae
Opuntia humifusa (Raf.) Raf. var. *humifusa* ○ – 21; V; *09-1177*

Campanulaceae
Campanula aparinoides Pursh var. ***aparinoides*** – 17; S; *09-817*
Campanula divaricata Michx. – 10; O; *08-1033*
‡*Campanula punctata* Lam. ++ – 24; V; *09-702*
**Campanula rapunculoides* L. ○ – 22; V; *09-578*
Campanulastrum americanum (L.) Small – 3; S; *09-1008*
Lobelia cardinalis L. – 14; O; *09-1009*
Lobelia inflata L. – 21; F; *08-1064*
Lobelia puberula Michx. var. *simulans* Fernald – 21; S; *09-958*
Lobelia siphilitica L. var. *siphilitica* – 22; F; *09-1004*
Lobelia spicata Lam. var. *scaposa* McVaugh – 21; R; *09-519*
Triodanis perfoliata (L.) Nieuwl. – 21; F; *09-646*

Cannabaceae
Celtis occidentalis L. ○ – 3; R; *10-137*
Humulus lupulus L. var. *lupuloides* E. Small ○ – 15; S; *08-1150*

Caprifoliaceae
***Lonicera ×bella* Zabel ○ – 22; V; *10-100*
Lonicera canadensis Bartram ex Marshall ○ – 3; V; *09-762*
***Lonicera japonica* Thunb. – 22; A; *09-563*
***Lonicera morrowii* A. Gray ○ – 22; I; *09-130*
^*Lonicera sempervirens* L. var. *sempervirens* ○ – 24; V; *10-326*
Symphoricarpos orbiculatus Moench – 21; O; *09-648*
Triosteum aurantiacum E.P. Bicknell var. *aurantiacum* ○ – 3; V; *10-185*
Triosteum perfoliatum L. ○ – 3; R; *10-282*

Caryophyllaceae
***Arenaria serpyllifolia* L. – 22; F; *07-146*
**Cerastium brachypetalum* Desp. ○ – 20; V; *10-52*
**Cerastium fontanum* Baumg. ssp. *vulgare* (Hartm.) Greuter & Burdet – 21; F; *08-181*
**Cerastium glomeratum* Thuill. – 22; O; *10-49*
Cerastium nutans Raf. – 3; S; *09-112*
**Cerastium semidecandrum* L. – 22; I; *09-448*
***Dianthus armeria* L. ssp. *armeria* – 21; F; *08-910*
**Dianthus barbatus* L. ssp. *barbatus* ○ – 21; R; *09-776*
**Holosteum umbellatum* L. ssp. *umbellatum* ○ – 20; R; *10-103*
Minuartia glabra (Michx.) Mattf. – 9; S; *09-458*
**Myosoton aquaticum* (L.) Moench – 21; O; *08-269*
Paronychia canadensis (L.) Alph. Wood – 7; O; *08-697*
Paronychia fastigiata (Raf.) Fernald var. *paleacea* Fernald ○ – 9; V; *09-626*
Sagina decumbens (Elliott) Torr. & A. Gray ○ – 22; F; *08-349*
**Sagina procumbens* L. ○ – 24; V; *10-442*
∞*Saponaria ocymoides* L. ++ – 24; V; *12-10*
**Saponaria officinalis* L. ○ – 22; A; *08-1293*
**Scleranthus annuus* L. ○ – 20; S; *07-139*
Silene antirrhina L. – 21; O; *09-708*
**Silene armeria* L. ○ – 21; R; *09-581*
**Silene coronaria* (L.) Clairv. ○ – 22; R; *10-288*
**Silene flos-cuculi* (L.) Clairv. ssp. *flos-cuculi* + – 21; S; *07-136*
**Silene latifolia* Poir. ○ – 22; F; *05-2312*
Silene stellata (L.) W.T. Aiton – 3; O; *08-1109*
Silene virginica L. – 22; F; *08-320*
**Silene vulgaris* (Moench) Garcke ○ – 21; S; *08-1319*
Stellaria corei Shinners ○ – 3; R; *09-239*
**Stellaria graminea* L. – 21; F; *10-169*
Stellaria longifolia Muhl. ex Willd. ++ – 21; R; *10-267*
**Stellaria media* (L.) Vill. – 20; A; *10-48*
**Stellaria neglecta* Weihe ○ – 20; S; *11-15*
Stellaria pubera Michx. – 3; F; *09-142*

Celastraceae
***Celastrus orbiculatus* Thunb. – 22; F; *08-531*
***Euonymus alatus* (Thunb.) Siebold ○ – 23; V; *10-68*
Euonymus americanus L. ○ – 2; S; *10-201*
***Euonymus fortunei* (Turcz.) Hand.-Mazz. ○ – 23; I; *09-502*
†*Euonymus japonicus* Thunb. – 23; V; *10-178*

Cistaceae
Crocanthemum canadense (L.) Britton ○ – 10; S; *09-1028B*
Crocanthemum propinquum (E.P. Bicknell) E.P. Bicknell – 10; V; *09-1028A*
Lechea racemulosa Michx. – 21; F; *09-1036*

Cleomaceae
**Tarenaya hassleriana* (Chodat) Iltis ○ – 22; R; *09-1161*

Clethraceae
Clethra acuminata Michx. – 10; I; *08-717*

Convolvulaceae
Calystegia catesbeiana Pursh ssp. *catesbeiana* ○ – 7; V; *10-259*
Calystegia sepium (L.) R. Br. ssp. *appalachiana* Brummitt ○ – 21; F; *08-829*
Calystegia silvatica (Kit.) Griseb. ssp. *fraterniflora* (Mack. & Bush) Brummitt ○ – 21; O; *08-543*
***Convolvulus arvensis* L. ○ – 21; R; *08-807*
Cuscuta campestris Yunck. – 22; I; *09-1082*
Cuscuta cephalanthi Engelm. ○ – 17; V; *09-997*
Cuscuta gronovii Willd. ex Schult. ○ – 21; F; *08-1178*
**Ipomoea coccinea* L. – 21; U; *FSE-RAB*
**Ipomoea hederacea* Jacq. ○ – 20; V; *08-1144*
Ipomoea pandurata (L.) G. Mey. – 22; I; *08-473*

****Ipomoea purpurea** (L.) Roth – 22; S; *08-1115*

Cornaceae
Cornus alternifolia L. f. – 3; I; *08-151*
Cornus amomum Mill. – 14; O; *11-165*
Cornus florida L. – 3; O; *09-169*
∞*Cornus kousa* Hance ○ – 24; R; *10-223*

Crassulaceae
Hylotelephium telephioides (Michx.) H. Ohba – 10; S; *09-932*
∞*Hylotelephium telephium* (L.) H. Ohba ○ – 23; R; *09-1021*
**Sedum acre* L. ○ – 21; R; *08-467*
**Sedum sarmentosum* Bunge ○ – 24; R; *05-720*
Sedum ternatum Michx. – 3; O; *08-341*

Cucurbitaceae
‡*Cucumis sativus* L. ○ – 20; V; *08-466*
‡*Cucurbita pepo* L. ○ – 20; S; *11-124*
Echinocystis lobata (Michx.) Torr. & A. Gray – 14; V; *09-824*
Sicyos angulatus L. – 21; O; *08-1037*

Diapensiaceae
Galax urceolata (Poir.) Brummitt – 7; A; *09-521*

Diervillaceae
Diervilla lonicera Mill. ○ – 10; V; *10-197*
∞*Weigela floribunda* (Siebold & Zuccarini) K. Koch ○ – 23; R; *10-183*

Dipsacaceae
***Dipsacus fullonum* L. ○ – 20; V; *08-500*

Droseraceae
Drosera rotundifolia L. var. *rotundifolia* – 17; I; *09-879*

Ebenaceae
Diospyros virginiana L. – 7; S; *10-358*

Elaeagnaceae
***Elaeagnus pungens* Thunb. ○ – 23; V; *10-31*
***Elaeagnus umbellata* Thunb. var. *parvifolia* (Royle) C.K. Schneid. ○ – 21; S; *10-158*

Ericaceae
Chimaphila maculata (L.) Pursh – 5; F; *08-1086*
Epigaea repens L. – 8; F; *09-31*
Eubotrys recurva (Buckley) Britton – 10; F; *08-688*
Gaultheria procumbens L. – 8; O; *08-831*
Gaylussacia baccata (Wangenh.) K. Koch – 8; F; *08-538*
Hypopitys monotropa Crantz ○ – 7; I; *08-679*
Kalmia buxifolia (P.J. Bergius) Gift, Kron, & P.F. Stevens – 11; X; *B.W. Wells s.n.* [NCSC, 11 September 1929]
Kalmia carolina Small – 17; S; *09-464*
Kalmia latifolia L. – 2; A; *09-1168*
Leucothoe fontanesiana (Steud.) Sleumer ○ – 2; R; *09-251*
Lyonia ligustrina (L.) DC. var. ligustrina – 17; F; *08-547*
Menziesia pilosa (Michx. ex Lam.) Juss. ex Pers. – 7; O; *08-698*
Monotropa uniflora L. ○ – 7; F; *08-753*
Monotropsis odorata Schwein. ex Elliott – 8; V; *09-13*
Oxydendrum arboreum (L.) DC. ○ – 5; F; *09-929*
†*Pieris japonica* (Thunb.) D. Don ex G. Don – 23; I; *12-04*
Pyrola americana Sweet – 2; S; *09-759*
Rhododendron arborescens (Pursh) Torr. ○ – 15; R; *09-694*
Rhododendron calendulaceum (Michx.) Torr. – 5; F; *08-198*
Rhododendron carolinianum Rehder ○ – 7; R; *09-194*
Rhododendron catawbiense Michx. – 7; A; *09-252*
Rhododendron maximum L. – 7; A; *09-706*
Rhododendron periclymenoides (Michx.) Shinners – 2; O; *10-101*
Rhododendron viscosum (L.) Torr. – 17; S; *09-517*
Vaccinium corymbosum L. – 7; F; *09-453*
Vaccinium erythrocarpum Michx. ○ – 10; R; *08-710*
Vaccinium fuscatum Aiton – 17; I; *09-437*
Vaccinium macrocarpon Aiton – 17; S; *08-586*
Vaccinium pallidum Aiton – 8; F; *08-174*
Vaccinium simulatum Small – 3; I; *09-1150*
Vaccinium stamineum L. – 10; F; *08-782*

Euphorbiaceae
Acalypha gracilens A. Gray ○ – 22; R; *10-481*
Acalypha rhomboidea Raf. – 20; O; *11-197*
Euphorbia corollata L. – 21; R; *10-430*
**Euphorbia cyparissias* L. ○ – 22; I; *09-92*
∞*Euphorbia dulcis* L. cv. 'Chameleon' ++ – 24; V; *07-150*
**Euphorbia lathyris* L. – 22; R; *10-351*
Euphorbia maculata L. – 24; A; *08-454*
Euphorbia nutans Lag. ○ – 22; F; *08-977*
Euphorbia pubentissima Michx. – 21; F; *08-541*

Fabaceae
***Albizia julibrissin* Durazz. ○ – 22; R; *08-828*
Amphicarpaea bracteata (L.) Fernald var. *bracteata* – 21; S; *11-154*
Amphicarpaea bracteata (L.) Fernald var. *comosa* Fassett – 21; F; *11-202*
Apios americana Medik. – 17; A; *08-730*
Astragalus canadensis L. var. *canadensis* – 3; R; *10-398*
Baptisia tinctoria (L.) Vent. – 21; I; *05-1631*
Cercis canadensis L. var. *canadensis* ○ – 21; S; *10-55*
Chamaecrista fasciculata (Michx.) Greene var. *fasciculata* – 22; R; *09-978*
Chamaecrista nictitans (L.) Moench var. *nictitans* – 22; I; *09-965*
Clitoria mariana L. var. *mariana* ○ – 5; V; *09-915*
Crotalaria sagittalis L. ○ – 8; V; *09-1071*
***Cytisus scoparius* (L.) Link ○ – 21; V; *08-228*
Desmodium ciliare (Muhl. ex Willd.) DC. ○ – 22; S; *09-993*
Desmodium glabellum (Michx.) DC. ○ – 22; F; *08-1221*
Desmodium marilandicum (L.) DC. – 22; I; *09-891*
Desmodium nuttallii (Schindl.) B.G. Schub. ○ – 22; R; *08-1219*
Desmodium paniculatum (L.) DC. var. *paniculatum* – 21; A; *08-1217*
Desmodium perplexum B.G. Schub. – 22; R; *08-984*
Desmodium rotundifolium DC. ○ – 5; R; *09-914*
Galactia volubilis (L.) Britton var. *volubilis* ○ – 8; V; *10-446*
^*Gleditsia triacanthos* L. ○ – 21; V; *08-496*
Hylodesmum glutinosum (Muhl. ex Willd.) H. Ohashi & R.R. Mill ○ – 3; R; *09-1061*
Hylodesmum nudiflorum (L.) H. Ohashi & R.R. Mill – 3; I; *08-1135*
***Kummerowia stipulacea* (Maxim.) Makino – 22; A; *08-858*
***Kummerowia striata* (Thunb.) Schindl. ○ – 22; A; *08-996*
**Lathyrus latifolius* L. ○ – 22; A; *03-03*
***Lespedeza bicolor* Turcz. – 22; F; *05-2307*
***Lespedeza cuneata* (Dum.-Cours.) G. Don ○ – 22; A; *10-463*
Lespedeza frutescens (L.) Hornem. ○ – 5; V; *08-785*
Lespedeza hirta (L.) Hornem. var. hirta – 22; S; *09-939*
Lespedeza procumbens Michx. ○ – 22; I; *08-923*
Lespedeza repens (L.) W.P.C. Barton ○ – 22; O; *09-994*
Lespedeza violacea (L.) Pers. – 5; F; *08-926*
***Lotus corniculatus* L. ○ – 22; R; *08-468*
***Medicago lupulina* L. ○ – 22; F; *09-149*
**Medicago sativa* L. – 20; I; *08-806*
***Melilotus albus* Medik. ○ – 22; F; *08-664*
***Melilotus officinalis* (L.) Pall. ○ – 22; F; *09-576*
Mimosa microphylla Dryand. ○ – 21; R; *09-778*
‡*Pisum sativum* L. ○ – 20; V; *09-1059*
***Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S.M. Almeida – 22; O; *08-1043*
Robinia hispida L. var. ***fertilis*** (Ashe) R.T. Clausen – 22; O; *09-726*
Robinia hispida L. var. *hispida* ○ – 22; S; *10-270*

Robinia hispida L. var. *rosea* Pursh – 5; S; *09-342*
Robinia pseudoacacia L. – 21; F; *09-358*
Securigera varia* (L.) Lassen ○ – 22; A; *08-851
Strophostyles umbellata (Muhl. ex Willd.) Britton ○ – 22; V; *10-476*
Stylosanthes biflora (L.) Britton, Sterns, & Poggenb. ○ – 21; R; *10-380*
**Trifolium aureum* Pollich ○ – 21; S; *09-554*
**Trifolium campestre* Schreb. ○ – 21; F; *08-358*
**Trifolium dubium* Sibth. ○ – 24; F; *08-279*
**Trifolium hybridum* L. ○ – 21; F; *08-116*
**Trifolium incarnatum* L. ○ – 21; R; *09-477*
**Trifolium pratense* L. – 21; A; *08-307*
**Trifolium repens* L. – 21; A; *08-311*
Vicia caroliniana Walter – 3; I; *09-62*
**Vicia hirsuta* (L.) Gray ○ – 22; V; *11-66*
Vicia sativa* L. ssp. *nigra* (L.) Ehrh. ○ – 21; F; *08-167
**Vicia villosa* Roth ssp. *varia* (Host) Corb. – 21; S; *09-535*
**Vicia villosa* Roth ssp. *villosa* ○ – 21; F; *10-274*
∞*Wisteria sinensis* (Sims) DC. ○ – 23; R; *10-77*

Fagaceae
Castanea dentata (Marshall) Borkh. ○ – 1; I; *08-718*
∞*Castanea mollissima* Blume ○ – 24; S; *08-979*
Castanea pumila (L.) Mill. – 8; I; *03-08*
Fagus grandifolia Ehrh. var. *caroliniana* (Loudon) Fernald & Rehder ○ – 2; O; *10-16*
Fagus grandifolia Ehrh. var. *grandifolia* ○ – 3; S; *10-127*
Quercus alba L. – 7; A; *08-1039*
Quercus coccinea Münchh. – 5; F; *11-147*
Quercus ilicifolia* Wangenh. ○ – 8; V; *08-1236
Quercus montana Willd. – 5; A; *08-1302*
^*Quercus palustris* Münchh. ○ – 24; V; *10-276*
^*Quercus phellos* L. ○ – 24; V; *10-277*
Quercus rubra L. var. *rubra* – 1; A; *09-425*
Quercus stellata Wangenh. – 5; S; *08-1343*
Quercus velutina Lam. – 5; I; *08-1344*

Fumariaceae
Adlumia fungosa* (Aiton) Greene ex Britton, Sterns, & Poggenb. – 3; V; *09-753
Capnoides sempervirens (L.) Borkh. – 10; S; *08-146*
Corydalis flavula (Raf.) DC. – 3; V; *J.E. Padgett 08-12* [BOON, 23 April 2008]
Dicentra canadensis (Goldie) Walp. – 3; R; *09-58*
Dicentra cucullaria (L.) Bernh. – 3; O; *09-67*

Gentianaceae
Bartonia paniculata (Michx.) Muhl. ssp. *paniculata* – 25; V; *P.D. McMillan 1* [NCU, 23 September 1992]
Bartonia virginica (L.) Britton, Sterns, & Poggenb. – 17; R; *09-06*
Gentiana austromontana J.S. Pringle & Sharp – 7; F; *08-1318*
Gentiana clausa Raf. – 3; S; *09-1044*
Gentiana decora Pollard – 7; U; *FSE-RAB*
Gentiana saponaria L. – 17; R; *09-1174*
Gentianella quinquefolia (L.) Small var. *quinquefolia* – 3; R; *09-1075*
Obolaria virginica L. – 3; R; *10-57*
Sabatia angularis (L.) Pursh ○ – 21; S; *09-827*

Geraniaceae
**Erodium cicutarium* (L.) L'Hér. – 22; R; *10-225*
Geranium carolinianum L. ○ – 21; I; *10-269*
**Geranium columbinum* L. ○ – 21; I; *09-641*
Geranium maculatum L. – 3; F; *08-185*
**Geranium molle* L. ○ – 21; I; *08-282*
∞*Geranium sanguineum* L. ○ – 24; V; *10-229*

Grossulariaceae
Ribes cynosbati L. – 3; R; *09-661*
^*Ribes hirtellum* Michx. ++ – 23; V; *09-14*
**Ribes rubrum* L. ○ – 22; S; *09-643*

Haloragaceae
Myriophyllum aquaticum* (Vell.) Verdc. ○ – 25; V; *09-472

Hamamelidaceae
Hamamelis virginiana L. var. *virginiana* – 3; F; *09-1157*

Hydrangeaceae
∞*Deutzia scabra* Thunb. ○ – 22; V; *10-232*
Hydrangea arborescens L. var. *arborescens* – 3; F; *08-1364*
†*Hydrangea arborescens* L. var. *grandiflora* Rehd. – 22; S; *09-1015*
∞*Hydrangea paniculata* Siebold ○ – 23; S; *08-1280*
^*Philadelphus inodorus* L. ○ – 23; R; *08-1077*

Hydrastidaceae
Hydrastis canadensis* L. – 3; V; *09-967

Hypericaceae
Hypericum canadense L. – 17; I; *08-1340*
Hypericum densiflorum Pursh – 17; F; *09-1171*
Hypericum gentianoides (L.) Britton, Sterns, & Poggenb. – 21; F; *07-785*
Hypericum mutilum L. var. *mutilum* – 14; F; *09-1180*
Hypericum perforatum* L. – 22; I; *09-625
Hypericum prolificum L. – 17; S; *08-946*
Hypericum punctatum Lam. – 22; F; *08-944*
Hypericum stragulum W.P. Adams & N. Robson ○ – 8; F; *08-770*
Hypericum virgatum Lam. – 17; V; *A.E. Radford 42784* [NCU, 17 July 1959]
Triadenum virginicum (L.) Raf. ○ – 25; V; *10-393*

Juglandaceae
Carya cordiformis (Wangenh.) K. Koch – 7; O; *08-790*
Carya glabra (Mill.) Sweet – 6; O; *08-721*
Carya ovalis (Wangenh.) Sarg. ○ – 7; I; *08-725*
Carya ovata (Mill.) K. Koch ○ – 7; I; *08-769*
Carya tomentosa (Lam. ex Poir.) Nutt. – 7; O; *08-865*
Juglans cinerea L. – 3; I; *08-754*
Juglans nigra L. – 3; F; *08-914*

Lamiaceae
Agastache scrophulariifolia (Willd.) Kuntze – 3; R; *08-662*
Ajuga reptans* L. ○ – 22; S; *10-66
Blephilia ciliata (L.) Benth. – 21; U; *FSE-CVS*
Blephilia hirsuta (Pursh) Benth. – 3; I; *08-481*
†*Clerodendrum trichotomum* Thunb. var. *ferrugineum* Nakai – 24; R; *11-141*
Clinopodium vulgare L. – 21; F; *09-1005*
Collinsonia canadensis L. – 3; O; *08-1103*
Cunila origanoides (L.) Britton – 7; S; *09-1032*
**Galeopsis bifida* Boenn. ○ – 21; V; *09-899*
Glechoma hederacea* L. – 22; A; *08-262
Hedeoma pulegioides (L.) Pers. – 7; O; *08-681*
Lamium amplexicaule* L. var. *amplexicaule* – 21; F; *09-02
**Lamium purpureum* L. ○ – 21; F; *08-164*
Leonurus cardiaca* L. – 22; S; *08-474
Lycopus ×sherardii Steele ○ – 21; F; *10-400*
Lycopus uniflorus Michx. – 21; O; *08-1189*
Lycopus virginicus L. – 22; I; *10-459*
**Marrubium vulgare* L. – 20; X; *A.E. Radford 44921* [BOON, 12 July 1966]
Meehania cordata* (Nutt.) Britton – 3; S; *09-639
**Melissa officinalis* L. ○ – 21; V; *10-366*
**Mentha ×gracilis* Sole (pro sp.) ○ – 21; V; *11-139*
Mentha ×piperita* L. (pro sp.) var. *piperita* – 14; I; *09-1010
**Mentha ×rotundifolia* (L.) Huds. – 21; R; *08-983*

**Mentha spicata* L. var. spicata ○ – 21; I; *10-414*
Monarda clinopodia L. – 3; F; *09-763*
Monarda didyma L. ○ – 3; S; *09-748*
Monarda fistulosa L. var. *mollis* (L.) Benth. – 21; O; *08-873*
Monarda punctata L. var. *punctata* – 21; V; *A. Mullen 7372* [UNCC, 1 September 1964]
***Nepeta cataria* L. – 22; O; *08-663*
□*Perilla frutescens* (L.) Britton var. *crispa* (Benth.) Deane ○ – 24; V; *11-240*
***Perilla frutescens* (L.) Britton var. *frutescens* ○ – 21; I; *08-1207*
Physostegia virginiana (L.) Benth. ssp. *praemorsa* (Shinners) P.D. Cantino ○ – 22; I; *08-890*
Physostegia virginiana (L.) Benth. ssp. *virginiana* – 22; R; *11-127*
**Prunella* aff. *laciniata* (L.) L. + – 21; V; *09-833*
Prunella vulgaris L. var. *lanceolata* (W.P.C. Barton) Fernald ○ – 21; F; *08-540*
***Prunella vulgaris* L. var. *vulgaris* – 22; F; *08-1080*
Pycnanthemum arkansanum Fresen. – 17; F; *08-1176*
Pycnanthemum beadlei (Small) Fernald ○ – 22; S; *09-1087*
Pycnanthemum incanum (L.) Michx. – 21; U; *FSE-RAB*
Pycnanthemum muticum (Michx.) Pers. – 17; I; *09-725*
Pycnanthemum pycnanthemoides (Leavenw.) Fernald var. *viridifolium* Fernald ○ – 22; I; *08-927*
Pycnanthemum tenuifolium Schrad. – 21; O; *08-1197*
Pycnanthemum verticillatum (Michx.) Pers. var. *verticillatum* ○ – 22; S; *09-987*
Pycnanthemum virginianum (L.) T. Durand & B.D. Jacks. ex B.L. Rob. & Fernald – 21; S; *08-572*
Salvia lyrata L. – 21; F; *08-138*
Scutellaria elliptica Muhl. ex Spreng. var. *elliptica* ○ – 7; O; *09-556*
Scutellaria incana Biehler – 7; U; *FSE-CVS*
Scutellaria integrifolia L. ○ – 21; O; *09-724*
Scutellaria lateriflora L. ○ – 14; I; *08-749*
Scutellaria saxatilis Riddell ○ – 3; S; *09-442*
Scutellaria serrata Andrews ○ – 3; S; *09-560*
Stachys appalachiana D.B. Poind. & J.B. Nelson + – 17; V; *09-739*
**Stachys byzantina* K. Koch ex Scheele ○ – 23; S; *08-1050*
***Stachys floridana* Shuttlew. ex Benth. ○ – 24; V; *09-701*
Stachys latidens Small ex Britton – 22; F; *08-451*
Teucrium canadense L. var. *canadense* – 22; I; *08-452*
Trichostema dichotomum L. – 21; I; *08-1322*

Lentibulariaceae
Utricularia subulata L. – 17; V; *09-898*

Linaceae
Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald ○ – 9; I; *10-348*
Linum striatum Walter – 17; O; *08-962*
Linum virginianum L. – 5; O; *08-783*

Linderniaceae
Lindernia dubia (L.) Pennell var. *dubia* – 25; I; *08-846*

Linnaeaceae
∞Abelia ×grandiflora (André) Rehder ○ – 23; V; *10-423*

Lythraceae
Cuphea viscosissima Jacq. – 22; R; *09-995*
†Lagerstroemia indica L. – 23; V; *10-440*
***Lythrum salicaria* L. ○ – 22; R; *10-458*

Malvaceae
**Abutilon theophrasti* Medik. – 20; S; *08-816*
∞Alcea rosea L. ○ – 22; R; *10-387*
ΔHibiscus moscheutos L. – 21; V; *09-1128*
†Hibiscus moscheutos L. cv. 'Disco Belle' – 22; V; *11-233*
**Hibiscus syriacus* L. ○ – 24; I; *08-1057*
**Malva moschata* L. ○ – 22; R; *08-888*
**Malva neglecta* Wallr. – 22; I; *08-346*
**Malva sylvestris* L. ○ – 22; R; *11-232*
Tilia americana L. var. *americana* ○ – 3; R; *11-70*
Tilia americana L. var. *heterophylla* (Vent.) Loudon – 3; F; *08-755*

Melastomataceae
Rhexia mariana L. var. *mariana* – 21; I; *09-986*

Menispermaceae
Menispermum canadense L. ○ – 3; V; *10-139*

Menyanthaceae
Menyanthes trifoliata L. – 18; V; *P.D. McMillan 7* [NCU, 28 August 1994]
**Nymphoides peltata* (S.G. Gmel.) Kuntze ++ – 25; R; *13-197*

Molluginaceae
**Mollugo verticillata* L. ○ – 20; O; *08-1143*

Montiaceae
Claytonia caroliniana Michx. – 3; A; *08-04*
Claytonia virginica L. var. *acutiflora* DC. ○ – 3; I; *08-10*
Claytonia virginica L. var. *virginica* – 3; A; *08-10A*
Phemeranthus teretifolius (Pursh) Raf. – 9; R; *09-771*

Moraceae
***Broussonetia papyrifera* (L.) L'Hér. ex Vent. ○ – 22; V; *10-234*
‡Fatoua villosa (Thunb.) Nakai – 24; V; *05-1628*
Maclura pomifera (Raf.) C.K. Schneid. – 23; V; *05-2267*
***Morus alba* L. ○ – 22; V; *10-407*
Morus rubra L. ○ – 3; I; *08-1010*

Myricaceae
Comptonia peregrina (L.) J.M. Coult. – 8; S; *05-1746*

Nyctaginaceae
∞Mirabilis jalapa L. cv. 'Broken Colors' ○ – 24; V; *06-229*

Nyssaceae
Nyssa sylvatica Marshall – 7; A; *08-864*

Oleaceae
Chionanthus virginicus L. – 10; S; *08-129*
**Forsythia viridissima* Lindl. ○ – 23; O; *09-49*
Fraxinus americana L. – 7; F; *08-720*
ΔFraxinus pennsylvanica Marshall – 24; V; *08-907*
***Ligustrum obtusifolium* Siebold & Zuccarini var. *suave* (Kitagawa) H. Hara ○ – 22; V; *10-308*
***Ligustrum sinense* Lour. ○ – 22; I; *09-525*
**Syringa vulgaris* L. ○ – 23; R; *09-127*

Onagraceae
Chamerion platyphyllum (Daniels) Á. Löve & D. Löve ○ – 22; V; *09-830*
Circaea alpina L. ssp. *alpina* ○ – 7; S; *09-663*
Circaea canadensis (L.) Hill ssp. *canadensis* – 3; O; *08-564*
Epilobium coloratum Biehler – 22; F; *09-943*
Epilobium leptophyllum Raf. – 17; I; *08-1175*
Gaura biennis L. – 22; O; *08-889*
Ludwigia alternifolia L. – 25; O; *08-495*
Ludwigia palustris (L.) Elliott – 14; O; *09-960*
Oenothera biennis L. – 21; F; *08-1148*
Oenothera fruticosa L. var. *fruticosa* – 17; O; *09-484*
Oenothera nutans G.F. Atk. & Bartlett ○ – 21; V; *11-131*
Oenothera parviflora L. ○ – 22; R; *08-1004*
∞Oenothera speciosa Nutt. ○ – 22; R; *11-117*
Oenothera tetragona Roth var. *tetragona* ○ – 21; I; *09-552*

Orobanchaceae
Agalinis decemloba (Greene) Pennell ○ – 21; V; *09-955*
Agalinis purpurea (L.) Pennell – 17; O; *09-950*

Agalinis tenuifolia (Vahl) Raf. var. *tenuifolia* ○ – 22; V; *I.W. Carpenter 542* [BOON, 29 August 1975]
Aureolaria laevigata (Raf.) Raf. – 7; O; *08-821*
Aureolaria virginica (L.) Pennell ○ – 3; V; *08-486*
Castilleja coccinea (L.) Spreng. – 21; V; *A.E. Radford 34178* [NCU, 30 May 1958]
Conopholis americana (L.) Wallr. – 3; F; *08-149*
Epifagus virginiana (L.) W.P.C. Barton ○ – 3; O; *09-1170*
Melampyrum lineare Desr. var. *americanum* (Michx.) Beauverd ○ – 8; S; *09-969*
Melampyrum lineare Desr. var. *latifolium* W.P.C. Barton – 22; F; *09-561*
Orobanche uniflora L. ○ – 3; S; *09-339*
Pedicularis canadensis L. – 21; S; *09-204*

Oxalidaceae
**Oxalis corniculata* L. ○ – 24; S; *10-263*
Oxalis dillenii Jacq. – 21; F; *10-262*
Oxalis florida Salisb. ○ – 21; S; *10-215*
Oxalis grandis Small ○ – 3; S; *10-268*
Oxalis stricta L. – 21; F; *10-227*
Oxalis violacea L. ○ – 3; I; *08-273*

Papaveraceae
‡*Papaver rhoeas* L. ○ – 22; V; *08-793*
Sanguinaria canadensis L. – 3; O; *09-36*

Parnassiaceae
Parnassia asarifolia Vent. – 17; S; *08-1225*
Parnassia grandifolia DC. – 17; R; *09-1051*

Passifloraceae
Passiflora lutea L. var. *lutea* ○ – 9; V; *09-1076*

Paulowniaceae
***Paulownia tomentosa* (Thunb.) Siebold & Zuccarini ex Steud. ○ – 22; S; *08-981*

Penthoraceae
Penthorum sedoides L. – 14; V; *A.E. Radford 40972* [NCU, 27 September 1958]

Phrymaceae
**Mazus pumilus* (Burm. f.) Steenis ○ – 24; V; *10-462*
Mimulus ringens L. var. *ringens* – 17; F; *08-938*
Phryma leptostachya L. var. *leptostachya* – 3; I; *08-788*

Phytolaccaceae
Phytolacca americana L. – 21; F; *08-838*

Plantaginaceae
**Antirrhinum majus* L. ○ – 24; R; *08-835*
Callitriche heterophylla Pursh var. *heterophylla* ○ – 25; V; *10-281*
Chelone cuthbertii Small – 17; I; *08-1224*
Chelone glabra L. ○ – 16; I; *08-1277*
Chelone lyonii Pursh – 11; V; *09-1173*
Chelone obliqua L. ○ – 18; V; *09-996*
**Cymbalaria muralis* (L.) G. Gaertn., B. Mey., & Scherb. ssp. *muralis* – 24; V; *03-15*
**Digitalis grandiflora* Mill. + – 25; R; *10-306*
**Digitalis purpurea* L. ○ – 23; S; *10-304*
†*Digitalis purpurea* L. cv. 'Campanulata' – 23; V; *10-204*
Gratiola neglecta Torr. ○ – 25; I; *08-843*
Gratiola viscidula Pennell – 25; R; *09-1158*
‡*Linaria maroccana* Hook. f. + – 21; V; *08-1232*
**Linaria vulgaris* Mill. ○ – 22; I; *08-857*
Nuttallanthus canadensis (L.) D.A. Sutton ○ – 21; V; *09-398*
Penstemon laevigatus Aiton ○ – 3; R; *10-272*
***Plantago aristata* Michx. – 21; S; *08-539*
***Plantago lanceolata* L. – 21; F; *08-1022*
**Plantago major* L. ○ – 22; O; *08-1210*
Plantago rugelii Decne. – 21; F; *08-529*
Plantago virginica L. – 21; O; *08-117*
Veronica americana Schwein. ex Benth. – 16; R; *09-831*
**Veronica arvensis* L. ○ – 21; F; *08-108*
**Veronica chamaedrys* L. – 22; V; *09-134*
***Veronica hederifolia* L. ○ – 22; R; *11-03*
**Veronica officinalis* L. – 21; F; *08-301*
Veronica peregrina L. var. *peregrina* – 21; F; *09-138*
**Veronica persica* Poir. ○ – 20; R; *10-130*
**Veronica serpyllifolia* L. var. *serpyllifolia* – 21; F; *08-107*
Veronicastrum virginicum (L.) Farw. – 22; S; *09-818*

Platanaceae
Platanus occidentalis L. var. *occidentalis* – 15; I; *08-297*

Podostemaceae
Podostemum ceratophyllum Michx. – 13; I; *08-462*

Polemoniaceae
Phlox carolina L. ○ – 22; R; *11-119*
Phlox glaberrima L. – 22; I; *09-587*
Phlox maculata L. var. *pyramidalis* (Sm.) Wherry – 14; S; *08-524*
Phlox ovata L. ○ – 22; S; *10-271*
Phlox paniculata L. ○ – 22; S; *08-885*
Phlox stolonifera Sims ○ – 3; S; *09-97*
^*Phlox subulata* ○ – 22; I; *09-44*

Polygalaceae
Polygala ambigua Nutt. – 22; R; *09-920*
Polygala cruciata L. var. *aquilonia* Fernald & B.G. Schub. – 17; S; *08-1227*
Polygala curtissii A. Gray – 22; S; *09-938*
Polygala sanguinea L. – 21; O; *07-787*

Polygonaceae
**Fagopyrum esculentum* Moench ○ – 19; V; *09-1095*
**Fallopia convolvulus* (L.) Á. Löve – 20; O; *10-415*
Fallopia cristata (Engelm. & A. Gray) Holub ○ – 21; S; *08-948*
Fallopia scandens (L.) Holub – 21; A; *08-1152*
Persicaria hydropiper (L.) Opiz – 14; F; *08-1117*
***Persicaria longiseta* (Bruijn) Kitag. – 21; F; *08-1040*
***Persicaria maculosa* Gray – 21; F; *08-1006*
Persicaria pensylvanica (L.) M. GóMez – 14; O; *10-404*
***Persicaria perfoliata* (L.) H. Gross + – 21; O; *10-417*
Persicaria punctata (Elliott) Small – 14; I; *08-1158*
Persicaria sagittata (L.) H. Gross ex Nakai – 21; F; *11-164*
Persicaria virginiana (L.) Gaertn. – 3; I; *08-1014*
**Polygonum aviculare* L. ssp. *aviculare* – 20; F; *08-661*
**Polygonum aviculare* L. ssp. *neglectum* (Besser) Arcang. ○ – 22; R; *10-457*
Polygonum buxiforme Small ○ – 22; S; *10-273*
Polygonum tenue Michx. ○ – 12; V; *09-1026*
***Reynoutria japonica* Houtt. ○ – 22; O; *08-855*
***Rumex acetosella* L. – 21; F; *08-281*
***Rumex crispus* L. ssp. *crispus* – 21; O; *09-435*
***Rumex obtusifolius* L. – 21; F; *08-1076*

Portulacaceae
**Portulaca grandiflora* Hook. ○ – 24; R; *10-363*
**Portulaca oleracea* L. ○ – 22; O; *10-413*

Primulaceae
Lysimachia ciliata L. – 21; F; *08-489*
**Lysimachia clethroides* Duby ○ – 22; R; *10-364*
Lysimachia lanceolata Walter – 10; S; *09-772*
***Lysimachia nummularia* L. ○ – 21; O; *09-553*
Lysimachia ×producta (Gray) Fern. – 17; R; *09-685*

Lysimachia quadrifolia L. – 7; F; *08-387*
Lysimachia terrestris (L.) Britton, Sterns, & Poggenb. – 17; O; *08-501*

Ranunculaceae
Aconitum uncinatum L. – 2; R; *09-889*
Actaea podocarpa DC. – 3; V; *09-1023*
Actaea racemosa L. – 2; O; *08-1030*
Anemone acutiloba (DC.) G. Lawson – 3; I; *08-17*
Anemone americana (DC.) H. Hara ○ – 3; V; *10-179*
Anemone lancifolia Pursh – 3; V; *10-181*
Anemone minima DC. ○ – 3; S; *10-62*
Anemone quinquefolia L. ○ – 3; O; *10-29*
Anemone virginiana L. var. *virginiana* – 3; O; *08-493*
Aquilegia canadensis L. – 3; O; *08-137*
∞*Aquilegia vulgaris* L. ○ – 22; V; *09-180*
Caltha palustris L. var. ***palustris*** – 18; U; *NCNHP*
******Clematis terniflora* DC. ○ – 23; O; *08-837*
Clematis viorna L. – 21; F; *09-558*
Clematis virginiana L. – 21; A; *08-735*
Coptis trifolia (L.) Salisb. var. ***groenlandica*** (Oeder) Fassett – 18; V; *09-248*
Delphinium exaltatum Aiton – 7; X; *P.O. Schallert 8672* [DUKE, 5 July 1924]
Delphinium tricorne Michx. ○ – 3; V; *09-167*
Ranunculus abortivus L. – 21; O; *08-99*
**Ranunculus acris* L. – 21; I; *09-410*
Ranunculus allegheniensis Britton – 2; O; *08-178*
******Ranunculus bulbosus* L. ○ – 21; O; *07-138*
Ranunculus carolinianus DC. – 15; V; *A.E. Radford 32733* [NCU, 2 May 1958]
Ranunculus hispidus Michx. – 3; O; *10-170*
**Ranunculus parviflorus* L. ○ – 21; V; *10-87*
Ranunculus recurvatus Poir. var. *recurvatus* – 14; F; *08-94*
**Ranunculus repens* L. – 21; F; *08-267*
Thalictrum clavatum DC. – 16; O; *08-101*
Thalictrum coriaceum (Britton) Small ○ – 3; V; *10-278*
Thalictrum dioicum L. – 3; I; *09-396*
Thalictrum macrostylum Small & A. Heller – 17; S; *08-569*
Thalictrum pubescens Pursh var. *pubescens* – 21; S; *09-636*
Thalictrum revolutum DC. – 21; F; *09-456*
Trautvetteria caroliniensis (Walter) Vail var. *caroliniensis* – 16; F; *09-568*
Xanthorhiza simplicissima Marshall – 14; A; *09-557*

Rhamnaceae
Ceanothus americanus L. var. *americanus* – 22; I; *08-1204*

Rosaceae
Agrimonia gryposepala Wallr. – 17; I; *09-799*
Agrimonia parviflora Aiton – 21; F; *08-799*
Agrimonia pubescens Wallr. – 17; O; *08-732*
Agrimonia rostellata Wallr. – 3; I; *08-792*
Amelanchier arborea (F. Michx.) Fernald – 5; O; *09-481*
Amelanchier laevis Wiegand – 7; I; *08-208*
**Aphanes australis* Rydb. ○ – 21; R; *10-214*
Aronia arbutifolia (L.) Pers. – 17; O; *09-977*
Aronia melanocarpa (Michx.) Elliott – 17; O; *09-905*
Aronia prunifolia (Marshall) Rehder – 17; S; *09-1105*
Aruncus dioicus (Walter) Fernald var. *dioicus* – 3; I; *09-567*
∞*Chaenomeles speciosa* (Sweet) Nakai ○ – 23; R; *09-46*
†*Cotoneaster* aff. *horizontalis* Decne. – 24; V; *08-476*
Crataegus chrysocarpa Ashe var. *dodgei* (Ashe) E.J. Palmer + – 21; R; *10-141*
Crataegus coccinea L. – 21; V; *08-272*
Crataegus crus-galli L. ○ – 21; R; *09-1053*
Crataegus intricata Lange var. *biltmoreana* (Beadle) R.W. Lance ○ – 21; V; *10-143*
Crataegus iracunda Beadle ○ – 3; O; *08-1162*
Crataegus macrosperma Ashe – 7; O; *08-211*
^*Crataegus phaenopyrum* (L. f.) Medik. ○ – 24; V; *06-253*
Crataegus pruinosa (H.L. Wendl.) K. Koch ○ – 21; I; *08-1161*
Crataegus punctata Jacq. ○ – 10; O; *08-361*
Fragaria virginiana Mill. – 21; F; *08-123*
Geum canadense Jacq. – 3; F; *08-703*
Geum donianum (Trattinick) Weakley & Gandhi – 3; V; *A.E. Radford 32723* [NCU, 2 May 1958]
Geum vernum (Raf.) Torr. & A. Gray ○ – 21; R; *08-236*
Geum virginianum L. – 3; O; *09-990*
Gillenia trifoliata (L.) Moench – 22; F; *08-363*
∞*Kerria japonica* (L.) DC. ○ – 23; V; *10-247*
Malus angustifolia (Aiton) Michx. ○ – 21; V; *08-197*
†*Malus* cf. *sieboldii* (Regel) Rehder – 21; V; *08-1317*
Malus coronaria (L.) Mill. – 21; F; *08-1194*
**Malus pumila* Mill. – 21; F; *08-657*
Physocarpus opulifolius (L.) Maxim. var. *opulifolius* – 14; O; *08-580*
Potentilla canadensis L. var. *canadensis* – 21; F; *08-184*
******Potentilla indica* (Andrews) Th. Wolf ○ – 24; O; *09-921*
Potentilla norvegica L. ○ – 21; O; *09-752*
******Potentilla recta* L. ○ – 21; O; *09-566*
Potentilla simplex Michx. – 21; F; *08-135*
**Poterium sanguisorba* L. ssp. *muricatum* (Spach) Rouy ○ – 21; V; *10-128*
Prunus americana Marshall ○ – 15; I; *08-449*
**Prunus avium* L. ○ – 22; S; *10-56*
**Prunus cerasifera* Ehrh. ○ – 21; R; *10-356*
†*Prunus domestica* L. – 24; R; *08-982*
∞*Prunus glandulosa* Thunb. ○ – 23; V; *09-129*
Prunus pensylvanica L. f. – 21; U; *FSE-CVS*
**Prunus persica* (L.) Batsch ○ – 22; S; *09-383*
Prunus serotina Ehrh. var. *serotina* – 3; F; *09-369*
†*Prunus serrulata* Lindl. – 24; I; *12-03*
**Prunus subhirtella* Miq. ○ – 22; R; *10-30*
∞*Prunus tomentosa* Thunb. + – 22; V; *11-05*
**Pyracantha coccinea* M. Roem. ○ – 21; R; *09-434*
□*Pyrus calleryana* Decne. ○ – 22; R; *10-53*
†*Pyrus communis* L. – 24; V; *09-66*
Rosa carolina L. ssp. *carolina* – 22; I; *09-565*
**Rosa luciae* Franch. & Rochebr. ex Crép. ○ – 22; F; *08-477*
******Rosa multiflora* Thunb. ex Murray – 21; A; *09-408*
Rosa palustris Marshall – 17; O; *08-459*
†*Rosa* sp. – 23; V; *09-689*
Rubus allegheniensis Porter – 21; I; *09-479*
Rubus canadensis L. – 17; U; *FSE-CVS*
Rubus dalibarda L. – 18; S; *09-541*
Rubus flagellaris Willd. – 22; O; *09-371*
Rubus hispidus L. – 18; A; *08-561*
Rubus occidentalis L. – 21; F; *08-478*
Rubus odoratus L. ○ – 3; R; *08-716*
Rubus pensilvanicus Poir. ○ – 21; F; *06-190*
******Rubus phoenicolasius* Maxim. ○ – 21; I; *06-192*
Sanguisorba canadensis L. – 17; I; *08-1168*
Sorbus americana Marshall – 10; I; *09-888*
Spiraea alba Du Roi – 17; I; *08-503*
Spiraea corymbosa Raf. – 7; U; *NCNHP*
******Spiraea japonica* L. f. var. *fortunei* (Planch.) Rehder ○ – 22; F; *08-485*
Spiraea latifolia (Aiton) Borkh. – 17; I; *08-826*
∞*Spiraea prunifolia* Siebold & Zuccarini ○ – 22; S; *09-30*
Spiraea tomentosa L. – 21; F; *08-533*
∞*Spiraea ×vanhouttei* (Briot) Carrière ○ – 22; R; *10-161*

Rubiaceae
Diodia teres Walter ○ – 21; I; *08-1065*
Diodia virginiana L. ○ – 21; R; *09-1074*

Galium anglicum Huds. ○ – 24; V; *07-141*
Galium aparine L. – 21; A; *09-402*
Galium asprellum Michx. – 17; I; *08-1183*
Galium circaezans Michx. var. *circaezans* – 7; F; *08-684*
Galium latifolium Michx. – 7; F; *08-702*
**Galium mollugo* L. var. *erectum* (Huds.) Domin – 21; R; *09-438*
**Galium mollugo* L. var. *mollugo* – 21; I; *06-183*
***Galium pedemontanum* (Bellardi) All. ○ – 21; F; *08-170*
Galium pilosum Aiton var. *pilosum* – 5; I; *08-894*
Galium tinctorium (L.) Scop. var. *floridanum* Wiegand – 17; O; *08-1278*
Galium tinctorium (L.) Scop. var. *tinctorium* – 17; O; *08-504*
Galium triflorum Michx. – 3; F; *08-480*
Houstonia caerulea L. – 7; F; *08-142*
Houstonia purpurea L. var. *purpurea* – 7; F; *08-348*
Houstonia pusilla Schoepf ○ – 21; V; *10-28*
Houstonia serpyllifolia Michx. – 18; O; *09-43*
Mitchella repens L. – 8; F; *11-01*

Rutaceae
Ptelea trifoliata L. var. *trifoliata* – 15; S; *08-950*

Salicaceae
***Populus alba* L. ○ – 21; R; *09-1178*
†*Populus ×canadensis* Moench (pro sp.) – 24; V; *09-652*
**Populus ×canescens* (Aiton) Sm. (pro sp.) – 22; S; *06-61*
Populus grandidentata Michx. – 4; R; *09-1106*
**Populus ×jackii* Sarg. ○ – 15; I; *08-970*
†*Populus maximowiczii* A. Henry – 24; V; *10-148*
†*Populus nigra* L. – 24; R; *09-1130*
†*Populus simonii* Carrière – 24; V; *08-932*
∞*Salix babylonica* L. ○ – 23; R; *09-505*
Salix humilis Marshall – 10; S; *12-47*
Salix nigra Marshall – 14; F; *08-268*
Salix sericea Marshall – 17; F; *08-945*

Santalaceae
Comandra umbellata (L.) Nutt. var. *umbellata* ○ – 5; V; *10-157*
Phoradendron leucarpum (Raf.) Reveal & M.C. Johnst. ssp. *leucarpum* – 5; R; *06-01*
Pyrularia pubera Michx. – 3; O; *08-194*

Sapindaceae
∞*Acer ginnala* Maxim. ○ – 22; V; *10-182*
Acer negundo L. var. *negundo* ○ – 15; S; *08-745*
Acer nigrum Michx. f. ○ – 15; V; *09-422*
Acer pensylvanicum L. – 1; O; *08-124*
†*Acer platanoides* L. – 24; R; *10-302*
Acer rubrum L. var. *rubrum* – 2; F; *08-1347*
Acer rubrum L. var. *trilobum* Torr. & A. Gray ex K. Koch ○ – 15; R; *09-473*
Δ*Acer saccharinum* L. – 24; I; *10-241*
Acer saccharum Marshall – 2; I; *09-644*
Aesculus flava Sol. – 3; F; *08-453*

Saxifragaceae
Boykinia aconitifolia Nutt. – 14; I; *08-568*
Chrysosplenium americanum Schwein. ex Hook. ○ – 16; V; *10-54*
Heuchera americana L. – 2; V; *A.E. Radford 38392* [NCU, 31 July 1958]
Heuchera hispida Pursh ○ – 3; I; *08-350*
Heuchera villosa Michx. var. *villosa* – 10; F; *08-704*
Hydatica petiolaris (Raf.) Small – 10; S; *08-171*
Micranthes caroliniana (A. Gray) Small – 11; I; *09-240*
Micranthes micranthidifolia (Haw.) Small ○ – 16; S; *09-389*
Micranthes virginiensis (Michx.) Small – 3; I; *08-130*
Mitella diphylla L. – 3; I; *09-163*
Tiarella cordifolia L. – 3; I; *09-392*

Scrophulariaceae
**Buddleja davidii* Franch. ○ – 22; R; *09-922*
Scrophularia marilandica L. – 3; S; *08-685*
**Verbascum blattaria* L. ○ – 22; F; *08-475*
**Verbascum phlomoides* L. ○ – 22; V; *10-362*
***Verbascum thapsus* L. – 22; F; *08-667*

Simaroubaceae
***Ailanthus altissima* (Mill.) Swingle ○ – 22; S; *08-1102*

Solanaceae
**Datura stramonium* L. ○ – 20; O; *08-805*
**Lycium chinense* Mill. ○ – 23; S; *09-1137*
‡*Nicotiana tabacum* L. ○ – 20; R; *09-1070*
∞*Petunia ×hybrida* Vilm. ○ – 22; V; *10-445*
Physalis grisea (Waterf.) M. Martínez – 20; I; *09-1055*
Physalis heterophylla Nees ○ – 22; R; *09-749*
Physalis longifolia Nutt. var. *subglabrata* (Mack. & Bush) Cronquist ○ – 21; R; *08-808*
Physalis pubescens L. var. *integrifolia* (Dunal) Waterf. ○ – 22; R; *10-419*
Solanum carolinense L. var. *carolinense* – 21; F; *11-168*
***Solanum dulcamara* L. – 21; O; *05-2298*
‡*Solanum lycopersicum* L. ○ – 24; V; *11-242*
Solanum ptychanthum Dunal ○ – 21; F; *08-811*
‡*Solanum tuberosum* L. ○ – 24; V; *08-443*

Styracaceae
Halesia tetraptera J. Ellis ○ – 3; I; *09-114*

Tropaeolaceae
‡*Tropaeolum majus* L. ○ – 24; V; *10-224*

Ulmaceae
Ulmus rubra Muhl. ○ – 15; I; *08-1122*

Urticaceae
Boehmeria cylindrica (L.) Sw. – 14; O; *08-747*
Laportea canadensis (L.) Wedd. – 3; I; *09-728*
Parietaria pensylvanica Muhl. ex Willd. – 7; U; *NCNHP*
Pilea pumila (L.) A. Gray – 18; O; *11-229*

Valerianaceae
Valerianella radiata (L.) Dufr. ○ – 21; O; *08-285*

Verbenaceae
Verbena hastata L. – 14; S; *08-542*
Verbena urticifolia L. – 21; F; *09-1067*

Violaceae
**Viola arvensis* Murray ○ – 21; I; *10-46*
Viola bicolor Pursh – 22; S; *09-20*
Viola blanda Willd. – 3; O; *09-117*
Viola canadensis L. var. *canadensis* – 3; O; *09-172*
Viola cucullata Aiton – 16; O; *08-204*
Viola hastata Michx. – 2; I; *09-35*
Viola hirsutula Brainerd – 2; O; *09-388*
Viola incognita Brainerd – 3; X; *A.E. Radford 32732* [NCU, 2 May 1958]
Viola labradorica Schrank – 21; V; *09-21*
Viola lanceolata L. – 17; U; *FSE-CVS*
Viola macloskeyi F.E. Lloyd var. *pallens* (Banks ex DC.) C.L. Hitchc. – 17; O; *08-202*
Viola palmata L. – 7; F; *10-166*
Viola pedata L. var. *pedata* – 21; O; *09-86*
Viola pensylvanica Michx. ○ – 3; F; *08-162*
Viola primulifolia L. – 21; O; *08-163*
Viola pubescens Aiton – 3; R; *10-168*
Viola rotundifolia Michx. – 2; F; *08-141*
Viola sagittata Aiton var. *ovata* (Nutt.) Torr. & A. Gray – 21; F; *09-87*
Viola sagittata Aiton var. *sagittata* – 21; I; *09-253*
Viola septentrionalis Greene ○ – 1; V; *10-198*
Viola sororia Willd. var. *missouriensis* (Greene) L.E. McKinney – 14; I; *10-63*

Viola sororia Willd. var. *sororia* – 21; F; *09-18A*
Viola striata Aiton – 22; F; *08-354*
Viola subsinuata Greene – 5; R; *09-177*
**Viola tricolor* L. ○ – 20; R; *10-102*

Vitaceae

Muscadinia rotundifolia (Michx.) Small var. *rotundifolia* ○ – 7; V; *09-205*
Parthenocissus quinquefolia (L.) Planch. – 21; F; *11-189*
**Parthenocissus tricuspidata* (Siebold & Zuccarini) Planch. ○ – 22; R; *10-264*
Vitis aestivalis Michx. var. *aestivalis* – 7; O; *J.L. Michael 578* [NCU, 23 May 1968]
Vitis aestivalis Michx. var. *bicolor* Deam ○ – 7; S; *11-239*
Vitis labrusca L. – 21; F; *08-237*
Vitis vulpina L. ○ – 14; F; *08-385*

CONCLUSIONS

Despite severe anthropogenic influence and a heavily modified landscape, Alleghany County has a wealth of floristic diversity. This is also quite remarkable in light of the very small size of this study area. Part of this high taxon diversity can be attributed to the rugged topography (inducing variable microclimates), disturbance (high exotic richness), and the geographic positioning of the county, which adds a physiographic "ecotone" effect (coupling of Mountain and Piedmont habitats). Ultimately, this flora is the most comprehensive survey for Alleghany County at present, but can in no way be considered complete due to human factors (missed taxa) and the dynamic nature of vegetation patterns (loss and gain of taxa over time). The usage of contemporary techniques, particularly the digital documentation and georeferencing aspect of this project, will hopefully serve as a model for making additional floristic projects more readily available, dynamic, and useful.

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VASCULAR PLANTS OF THE CANYONLANDS UNIT OF THE BIG THICKET NATIONAL PRESERVE, TYLER COUNTY, TEXAS

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ABSTRACT

This is the first annotated checklist of the vascular plants of the Canyonlands Unit of the Big Thicket National Preserve located in southeast Texas. The Unit lies entirely within Tyler County, comprising 597.3 hectares. Currently this unit has 103 families, 246 genera, 388 species and 16 that are subspecies or varieties. Twenty nine of these 388 species are introduced to North America and 3 species are listed as noxious/invasive. The species are assembled into an annotated checklist including species origin, longevity and season of growth.

RESUMEN

Se presenta el primer catálogo de las plantas vasculares de la Unidad de Canyonlands de la Big Thicket National Preserve. La Big Thicket National Preserve está ubicada en el sureste de Texas. La Unidad de Canyonlands se encuentra totalmente dentro de el condado de Tyler, Texas comprendiendo 597.3 hectáreas. Actualmente esta unidad cuenta con 103 familias, 246 géneros, 388 especies, y 16 subespecies o variedad, de las que 29 son especies introducidas a América del Norte y 3 de estas especies son invasoras. Las especies se agrupan en una lista comentada con el origen de la especie, la longevidad y la temporada de crecimiento.

INTRODUCTION

This paper provides the first checklist of the vascular plants in the Canyonlands Unit of the Big Thicket National Preserve. The checklist will be utilized by ecologists and botanists interested in the flora of the Big Thicket National Preserve and southeastern Texas. It provides a list of plants that are currently found within this area. Wildlife biologists and wildlife ecologists can benefit from this checklist by using the data for implementing management practices within the unit. This information could also be helpful in determining the different wildlife species within the area. The checklist indicates the invasive/noxious plant species in the area and can serve as a starting point for tracking and managing these invasive species.

SITE DESCRIPTION

The Big Thicket National Preserve is located in the Pineywoods vegetation area (Hatch et al. 1990) of southeastern Texas. Established in 1974, it became America's first National Preserve with approximately 34,803 hectares (Peacock 1994). In 1981 the Preserve was designated a UNESCO Biosphere Reserve by the United Nations, and in 2001 the American Bird Conservancy designated the preserve as a Globally Important Bird Area. Today the preserve consists of just over 40,468.6 hectares, comprising 15 units that spread over parts of seven different counties in eastern Texas (Watson 2006). This project focuses on the Canyonlands Unit of the Big Thicket National Preserve (Fig. 1). The Big Thicket National Preserve acquired the Canyonlands Unit in 1993. It consists of 597.3 hectares, located on the eastern border of Tyler County along 5.63 km of the Neches River, on the east side of the unit.

Within these hectares are a variety of environments, including upland habitat (Fig. 2), wetland and riparian areas (Fig. 3), cypress swamps and pineywoods (Fig. 3). The Canyonlands Unit is made up of various canyons and topography changes with elevations ranging from 18.3–61 m above sea level. A floristic study was conducted on this unit to determine the number of the vascular plant species within the Canyonlands Unit. This floristic study occurred over parts of four years, November 2008–November 2011.

The climate for this area is described as subtropical (MacRoberts 2008). The average temperature for Tyler

County is 18.8–20°C with an average annual rainfall of 127–137 cm (CoCoRaHS 2012). This region has the highest average annual rainfall in Texas (MacRoberts 2008). However, during the study period this area of Texas received below average rainfall for both 2010 and 2011, 93 cm and 79 cm respectively.

The Canyonlands Unit is made up of a variety of 20 different soil types: sand, silt, clay or a combination of all three. The most abundant soil is the Estes Angelina Complex, which makes up 36% of the unit. It is a clay-dominated soil and is found in the bottomlands and low-lying areas. The second most abundant soil is the Woodville Fine Sandy Loam, which occurs on the slopes of the main canyons within the unit. For more specifics on soils, see Haile (2012).

METHODS

Eleven collection trips were made over the three year period. Trips were made during the different growing seasons in order to collect plant species while they were in flower and/or fruit. Each collection site within the unit was visited several times throughout the project to make a more complete checklist of the vascular plants within the Canyonlands Unit (Haile 2012). A voucher specimen and/or a photo were taken to document the species within the unit. The specimens of each species included in this checklist are housed in the S.M. Tracy Herbarium (Texas A&M University) including other holdings of the National Park Service.

Collection sites were determined based on soils, topography, and vegetation communities in an area. During collection trips up to four collectors were present in order to better cover each location. At each site the collectors would collect all the flowering vascular plant species that had not previously been collected. Once collections were made, each specimen received collection numbers, site descriptions, an associated species list, soil description and GPS locations. Before leaving the site, each specimen was pressed in a plant press and set to dry, later keyed, identified and verified.

Identifications for the species were made by using the following books, including: *Illustrated Flora of North Central Texas* (Diggs et al. 1999), *Illustrated Flora of East Texas, Volume 1* (Diggs et al. 2006), *Aquatic and Wetland Plants of Southeastern United States*: Dicotyledons (Godfrey & Wooten 1981), *Aquatic and Wetland Plants of Southeastern United States: Monocotyledons* (Godfrey & Wooten 1979), and *Gould's Grasses of Texas* (Hatch 2010), *Trees, Shrubs, & Woody Vines of East Texas* (Nixon 1985). Hatch (2010) was used for the current scientific names of all the Poaceae. The current scientific names for all other families and species were found at USDA Plants, and Diggs et al. (1999, 2006). Angiosperm Phylogeny Group (APG) classification system was used for placement of genera within families (Angiosperm Phylogeny website).

RESULTS AND DISCUSSION

The Canyonlands Unit has 103 families, 246 genera, and 388 species and 16 infraspecific taxa (Appendix 1). Figure 4 and Figure 5 are two species collected and documented for the unit. Of these 388 species, 29 are introduced and 3 are considered invasive/noxious. An invasive species is defined as a plant whose introduction causes or is likely to cause economic harm, environmental harm, or harm to human health (www.invasive.org). Invasive species are weedy species; they can be either native or introduced. The plants listed as invasive species are listed on the invasive and noxious weed list for Texas (USDA Plants).The four largest families in this unit were Poaceae (68 species), Asteraceae (43 species), Cyperaceae (23 species), and Fabaceae (18 species).

Floristic studies and the resulting species checklist of an area are never complete. It is estimated that this list includes 90 percent of the plant species within the unit. Due to the dry weather conditions that occurred during this study, some of the cool season annuals may not have been observed and collected. The next goal is to make future collecting trips to this unit in order to continue to add to this species checklist.

Appendix 1 is the annotated checklist of the vascular plant species observed and collected within the Canyonlands Unit of the Big Thicket National Preserve. The voucher specimens are housed at the S.M. Tracy Herbarium (TAES). The checklist is arranged first by phylum (Pteridophyta, Pinophyta, Magnoliophyta). Families are arranged alphabetically within phylum, genera are arranged alphabetically within family, and species are arranged alphabetically within each genus. The scientific name and authority is given for each of the species (Hatch et al. 1990; Diggs et al. 1999; Diggs et al. 2006; Hatch 2010), along with the longevity, origin,

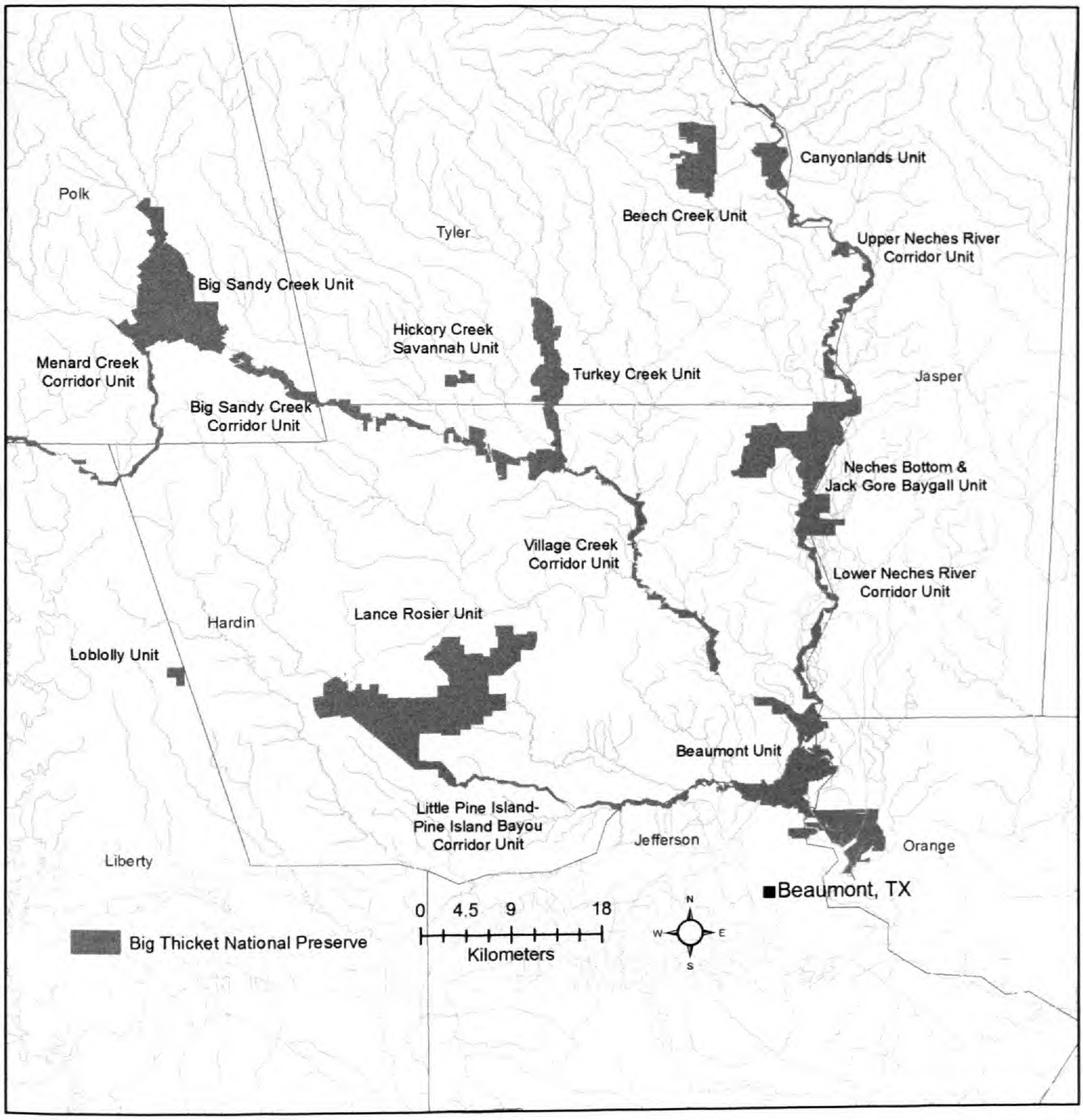


Fig. 1. Location of the Canyonlands Unit of the Big Thicket National Preserve, Tyler County, Texas.

and season of growth (Hatch et al. 1990). The invasive status for each of the species is denoted in the Appendix. Along with the above information, the collector's name and collection number are included in the checklist for each of the species.

APPENDIX 1

ANNOTATED LIST OF VASCULAR PLANTS

The checklist is broken into the major groups of vascular plants (Pteridophyta, Pinophyta, Magnoliophyta: Liliopsida, Magnoliopsida). Abbreviations used in the annotated checklist are as follows. **Collectors: AG** = Aminda Gallardo, **DK** = Dale Kruse, **KH** = Kelly Haile, **LB** = Larry Brown, **PR** = Paul Roling, **SH** = Stephan Hatch. **Origin: N** = Native, **I** = Introduced, **Longevity: A** = Annual, **P** = Perennial. **Season of Growth: W** = Warm-season growth, **C** = Cool-season growth, * = **I** nvasive species.



Fig. 2. Uphill view of a canyon in the southern end of the Canyonlands Unit of the Big Thicket National Preserve, Tyler County, Texas (photo by S.L. Hatch).

PTERIDOPHYTA

Aspleniaceae
Asplenium platyneuron (L.) B.S.P, SH 10696 a; N, P, W

Blechnaceae
Woodwardia areolata (L.) T. Moore, KH 626; N, P, W

Dryopteridaceae
Polystichum acrostichoides (Michx.) Schott, SH 10758; N, P, W

Osmundaceae
Osmunda cinnamomea L., AG 635; N, P, W
Osmunda regalis L., SH 10683; N, P, W

Polypodicaeae
Pleopeltis polypodioides (L.) Andrews & Windham, AG 523; N, P, W

Pteridaceae
Pteris multifida Poir., KH 459; I, P, W

Schizaeaceae
**Lygodium japonicum* (Thunb.) Sw., AG 580; I, P, W

Thelypteridaceae
Thelypteris kunthii (Desv.) Morton, SH 10686; N, P, W

Woodsiaceae
Athyrium filix-femina (L.) Roth, SH 10831; N, P, W
Onoclea sensibilis L., KH 628; N, P, W

PINOPHYTA

Cupressaceae
Juniperus virginiana L., KH 815; N, P, W
Taxodium distichum (L.) Rich., AG 600; N, P, W

Pinaceae
Pinus echinata Mill., AG 571; N, P, W
Pinus taeda L., AG 611; N, P, W

MAGNOLIOPHYTA: LILIOPSIDA

Agavaceae
Yucca louisianensis Trel., SH 10797; N, P, C

Alismataceae
Sagittaria platyphylla (Engelm.) J.G. Smith, KH 476 b; N, P, W

Alliaceae
Allium canadense L., SH 10766; N, P, C
Aletris aurea Walter, LB; N, P, W
Nothoscordum bivalve (L.) Britton, AG 615; N, P, C

Araceae
Arisaema dracontium(L.) Schott, KH 681; N, P, C
Arisaema triphyllum (L.) Schott, AG 642; N, P, C

Arecaceae
Sabal minor (Jacq.) Pers., SH 10751; N, P, W



Fig. 3. Bottomland area within the Canyonlands Unit of the Big Thicket National Preserve, Tyler County, Texas (Photo by S.L. Hatch).

Bromeliaceae
Tillandsia usneoides (L.) L., KH 415; N, P, W

Burmanniaceae
Apteria aphylla (Nutt.) Barnh. ex Small, AG 528; N, P, W

Commelinaceae
Commelina erecta L. var. *angustifolia* (Michx.) Fernald, KH 483; N, P, W
Commelina erecta L. var. *erecta,* SH 10650; N, P, W
Tradescantia hirsutiflora Bush, AG 420; N, P, C

Cyperaceae
Carex basiantha Steud., KH 675; N, P, C
Carex caroliniana Schwein., KH 713; N, P, C
Carex debilis Michx., KH 481; N, P, C
Carex frankii Kunth, KH 799; N, P, W
Carex glaucescens Elliott, AG 575; N, P, W
Carex leptalea Wahl., DK 1807; N, P, C
Carex louisianica L.H. Bailey, KH 544; N, P, C
Carex lupulina Willd., SH 10848; N, P, W
Carex scabrata Schwein., KH 547; N, P, W
Carex styloflexa Buckl., LB; N, P, C
Carex tribuloides Wahlenb., KH 763; N, P, C
Cyperus esculentus L., KH 477 b; N, P, W
Cyperus haspan L., KH 463; N, P, W
Cyperus plukenetii Fernald, KH 610; N, P, W
Cyperus retrorsus Chapm., KH 640; N, P, W
Cyperus virens Michx., KH 458; N, P, W
Rhynchospora caduca Elliott, AG 525; N, P, W
Rhynchospora globularis (Chapm.) Small, SH 10778; N, P, W
Rhynchospora glomerata (L.) Vahl, KH 430; N, P, W
Rhynchospora harveyi W. Boott, KH 715; N, P, W
Scirpus cyperinus (L.) Kunth, KH 459; N, P, W
Scleria oligantha Michx., SH 10813; N, P, C
Scleria triglomerata Michx., KH 430 a; N, P, C

Hypoxidaceae
Hypoxis hirsuta (L.) Coville, KH 870; N, P, C
Hypoxis curtissii Rose, LB; N, P, C

Iridaceae
Sisyrinchium campestre E.P. Bicknell, AG 623; N, P, C
Sisyrinchium langloisii Greene, SH 10669; N, P, C

Juncaceae
Juncus acuminatus Michx, SH 10847; N, P, C
Juncus coriaceus Mack., KH s.n.; N, P, C
Juncus effusus L., KH 479; N, P, W
Juncus polycephalus Michx., SH 10851; N, P, W
Luzula echinata (Small) F.J. Herm., SH 10821; N, P, C

Melanthiaceae
Trillium gracile J.D. Freeman, KH 704; N, P, C

Orchidaceae
Cypripedium kentuckiensis Reed, PR; N, P, W
Platanthera clavellata (Michx.) Luer, PR; N,P,W



Fig. 4. *Rhododendron canescens* in the Canyonlands Unit of the Big Thicket National Preserve, Tyler County, Texas (Photo by Robert Haile).

Poaceae

Agrostis elliottiana Schult., KH 691; N, A, C
Andropogon gerardii Vitman, KH 637; N, P, W
Andropogon glomeratus (Walter) Britton, KH s.n.; N, P, W
Andropogon gyrans Ashe, KH s.n.; N, P, W
Andropogon ternarius Michx., KH 601; N, P, W
Andropogon virginicus L., KH 549; N, P, W
Aristida lanosa Muhl. ex Elliott, KH 606; N, P, W
Aristida longespica Poir. var. *longespica,* KH 572; N, A, W
Aristida oligantha Michx., KH 588; N, A, W
Aristida purpurascens Poir. var. *purpurascens,* AG 510; N, P, W
Arundinaria gigantea (Walter) Muhl., KH 701; N, P, C
Axonopus fissifolius (Raddi) Kuhlm., SH 10655; N, P, W
Brachyelytrum erectum (Schreber) P. Beauv., SH 10839; N, P, C
Briza minor L., SH 10733; I, A, C
Chasmanthium latifolium (Michx.) Yates, AG 606; N, P, W
Chasmanthium laxum (L.) Yates, AG 520; N, P, W
Cynodon dactylon (L.) Pers., KH s.n.; I, P, W
Dichanthelium aciculare (Desv. ex Poir.) Gould & C. Clark var. *aciculare*, SH 10682; N, P, C
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *acuminatum*, SH 10651; N, P, C
Dichanthelium boscii (Poir.) Gould & C.A. Clark, SH 10763; N, P, C
Dichanthelium clandestinum (L.) Gould, SH 10692; N, P, C
Dichanthelium commutatum (Schult.) Gould, KH 501; N, P, C
Dichanthelium dichotomum (L.) Gould var. *dichotomum,* SH 10843; N, P, C
Dichanthelium dichotomum (L.) Gould var. *lucidium* (Ashe) Freckmann & Lelong, SH 10692; N, P, C
Dichanthelium dichotomum (L.) Gould var. *microcarpon* (Muhl. ex Elliott) Freckmann and Lelong, KH s.n., N, P, C
Dichanthelium laxiflorum (Lam.) Gould, AG 519; N, P, C



Fig. 5. *Sabatia campestris* in the Canyonlands Unit of the Big Thicket National Preserve, Tyler County, Texas (Photo by Robert Haile).

Dichanthelium nodatum (A. Hitchc. & Chase) Gould, KH 655; N, P, C
Dichanthelium oligosanthes (Schult.) Gould, SH 10800; N, P, C
Dichanthelium portoricense (Desv. ex Ham.) B.F. Hansen & Wunderlin, SH 10744; N, P, C
Dichanthelium ravenelii (Scribn. & Merr.) Gould, SH 10808; N, P, C
Dichanthelium sphaerocarpon (Elliott) Gould, SH 10772; N, P, C
Digitaria ischaemum (Schreb.) Schreb. ex Muhl., KH 610; N, P, W

Echinochloa walteri (Pursh) A. Heller, KH 636; N, A, W
Eragrostis capillaris (L.) Nees, KH 657; N, A, W
Eragrostis refracta (Muhl.) Scribn., KH 559; N, P, W
Eragrostis secundiflora J. Presl, KH 564; N, P, W
Eragrostis spectabilis (Pursh) Steud., AG 506; N, P, W
Gymnopogon ambiguus (Michx.) B.S.P., AG 571; N, P, W
Leersia lenticularis Michx., AG 589; N, P, W
Leersia oryzoides (L.) Sw., KH 638; N, P, W
Leersia virginica Willd., KH 522; N, P, W
Lolium perenne L., KH s.n.; I, A, C
Melica mutica Walter, KH 668; N, P, W
Mnesithea cylindrica (Michx.) Koning & Sosef, SH 10807; N, P, W
Oplismenus hirtellus (L.) P. Beauv., KH 512; I, P, W
Panicum anceps Michx., KH 853; N, P, W
Panicum brachyanthum Steud., KH 557; N, P, W
Panicum gymnocarpon Elliott, AG 599; N, P, W
Panicum hemitomon Schult., KH 880; N, P, W
Panicum hians Elliott, KH s.n.; N, P, W
Panicum rigidulum Bosc ex Nees, AG 574; N, P, W
Panicum verrucosum Muhl., AG 573; N, A, W
Paspalum floridanum Michx., AG s.n.; N, P, W
Paspalum fluitans (Elliott) Kunth, AG 593; N, A, W
Paspalum notatum Fluggé, KH s.n; I, P, W
Paspalum plicatulum Michx., KH s.n.; N, P, W
Paspalum setaceum Michx. var. *muhlenbergii* (Nash) D. Banks, AG 595; N, P, W
Paspalum setaceum Michx. var. *setaceum* (Nash) D. Banks, KH 556; N, P, W
Paspalum setaceum Michx. var. *stramineum* (Nash) D. Banks, AG 567; N, P, W
Paspalum urvillei Steud., SH 10809; I, P, W
Piptochaetium avenaceum (L.) Parodi, SH 10742; N, P, C
Poa annua L., AG 655; I, A, C
Poa autumnalis Muhl. ex Elliott, KH 702; N, P, C
Saccharum baldwinii Spreng., KH 630; N, P, W
Schizachyrium scoparium (Michx.) Nash, AG 509; N, P, W
Sorghastrum elliottii (C. Mohr) Nash, KH 609; N, P, W
Sphenopholis filiformis (Chapm.) Scribn., AG 608; N, P, C
Sphenopholis longiflora (Vasey) A. Hitchc., SH 10708; N, P, C
Sporobolus compositus (Poir.) Merr. var. *clandestinus* (Biehler) Wipff & S.D. Jones, KH 560; N, P, W
Sporobolus indicus (L.) R. Br., AG 560; I, P, W
Tridens flavus (L.) A. Hitchc. var. *chapmanii* (Small) Shinners, SH 10810; N, P, W
Tridens flavus (L.) A. Hitchc. var. *flavus*, KH s.n.; N, P, W
Vulpia octoflora (Walter) Rydb., SH 10731; N, A, C

Pontederiaceae
**Eichhornia crassipes* (Mart.) Solms, KH 634; I, P, W

Smilacaceae
Smilax bona-nox L., KH 846; N, P, C
Smilax glauca Walter, KH 594; N, P, C
Smilax laurifolia L., KH 614; N, P, C
Smilax pumila Walter, KH 741; N, P, C
Smilax rotundifolia L., KH 796; N, P, C
Smilax smallii Morong, KH 604; N, P, C
Smilax walteri Pursh, KH 797; N, P, C

Typhaceae
Typha domingensis Pers., KH s.n.; N, P, W
Typha latifolia L., KH 488; N, P, W

Xyridaceae
Xyris jupicai Rich., KH 457; N, P, W

MAGNOLIOPHYTA: MAGNOLIOPSIDA

Acanthaceae
Justicia ovata (Walter) Lindau., KH 470; N, P, W
Ruellia caroliniensis (Gmel.) Steud., SH 10718; N, P, W

Adoxaceae
Sambucus nigra L. subsp. *canadensis* (L.) R. Bolli, SH 10854; N, P, W

Altingiacaeae
Liquidambar styraciflua L., AG 531; N, P, C

Anacardiaceae
Rhus copallina L., KH 774; N, P, W
Toxicodendron radicans (L.) O. Ktze., SH photo; N, P, C

Annonaceae
Asimina parviflora (Michx.) Dunal, KH 443; N, P, C
Asimina triloba (L.) Dunal, KH 10684; N, P, C

Apiaceae
Chaerophyllum tainturieri Hook., AG 661; N, A, C
Cyclospermum leptophyllum (Pers.) Sprague ex Britton & P. Wilson, KH 752; I, A, W
Hydrocotyle verticillata Thumb., SH 10694; N, P, W

Apocynaceae
Amsonia glaberrima Woods. KH 759; N, P, W
Amsonia tabernaemontana Walter, LB; N, P, C
Asclepias perennis Walter, KH 751; N, P, W
Asclepias tuberosa L., SH 10713; N, P, W
Cynanchum laeve (Michx.) Pers., SH 10709; N, P, W
Trachelospermum difforme (Walter) A. Gray, SH 10894; N, P, W

Aquifoliaceae
Ilex coriacea (Pursh.) Chapm., KH 772; N, P, C
Ilex decidua Walter, KH 660; N, P, C
Ilex longipes Chapm. ex Trel., LB; N, P, C
Ilex opaca Soland., KH 425; N, P, C
Ilex vomitoria Soland., AG 522; N, P, C

Araliaceae
Aralia spinosa L., SH 10762; N, P, W

Asteraceae
Ambrosia psilostachya DC., KH 418 b; N, P, W
Amphiachyris dracunculoides (DC.) Nutt., KH 435; N, A, C
Baccharis halimifolia L., KH s.n.; N, P, W
Berlandiera betonicifolia (Hook.) Small, KH 409; N, P, C
Berlandiera pumila (Michx.) Nutt., SH 10738; N, P, C
Chrysopsis pilosa Nutt., KH 451; N, A, W
Cirsium horridulum Michx., KH 704; N, P, C
Conoclinum coelestinum (L.) Schott, KH 648; N, P, C
Conyza canadensis (L.) Cronquist, KH s.n.; N, A, W
Coreopsis grandiflora Sweet, SH 10762; N, P, C
Coreopsis linifolia Nutt., KH 645; N, P, C
Croptilon divaricatum (Nutt.) Raf., KH 568; N, A, W
Elephantopus carolinianus Raeusch., KH 420; N, P, W
Elephantopus nudatus A. Gray, KH 625; N, P, W
Erechtites hieraciifolia (L.) Raf. ex DC., AG 528; N, P, W
Erigeron strigosus Muhl. ex. Willd., KH 851; N, A, C
Eupatorium capillifolium (Lam.) Small, KH 548; N, P, W
Eupatorium perfoliatum L., SH 10855; N, P, W
Eupatorium rugosum Houtt., KH 578; N, P, W
Gaillardia aestivalis (Walter) H. Rock, KH 777; N, P, W
Gamochaeta purpurea (L.) Cabrera, KH 719; N, A, W
Helenium amarum (Raf.) H. Rock, SH 10729; N, A, W
Helenium elegans DC., SH 10857; N, A, W
Helianthemum carolinianum (Walter) Michx., LB; N, P, C
Helianthus angustifolius L., KH s.n.; N, P, W

Helianthus pauciflorus Nutt., KH 853 b; N, P, W
Heterotheca subaxillaris (Lam.) Britt. & Rusby, SH 10679; N, A, W
Hymenopappus artemisiifolius DC., SH 10717; N, P, W
Krigia occidentalis Nutt., KH 673; N, A, C
Krigia virginica (L.) Willd., LB; N, A, C
Liatris elegans (Walter) Michx., KH 435; N, P, W
Mikania scandens (L.) Willd., KH 525; N, P, W
Parthenium hysterophorus L., KH 646; N, A, W
Pityopsis graminifolia (Michx.) Nutt., KH 563; N, P, W
Pluchea camphorata (L.) DC., KH 517; N, P, W
Pluchea foetida (L.) DC., KH 529; N, P, W
Pyrrhopappus carolinianus (Walter) DC., SH 10730; N, A, W
Rudbeckia hirta L., KH 718; N, P, W
Solidago auriculata Shuttlew ex Blake, KH 530; *N, P, W*
Sonchus asper (L.) Hill, LB; I, A, W
Verbesina virginica L., KH 727; N, P, W
Vernonia missurica Raf., KH 513 a; N, P, W
Vernonia texana (A. Gray) Small, KH 857; N, P, W

Berberidaceae
Podophyllum peltatum L., AG 611; N, P, C

Betulaceae
Alnus serrulata (Dryand ex Ait.) Willd., AG 524; N, P, C
Carpinus caroliniana Walter, KH 763; N, P, C
Ostrya virginiana (Mill) K. Koch, KH 666; N, P, C

Bignoniaceae
Bignonia capreolata L., KH 466; N, P, C
Campsis radicans (L.) Seem ex Bureau, AG 582; N, P, W

Boraginaceae
Cynoglossum virginianum L., KH 859; N, P, C
Heliotropium indicum L., KH 635; I, P, W
Myosotis macrosperma Engelm., AG 660; N, A, C

Brassicaceae
Cardamine bulbosa (Schreb. ex Muhl.) Britton, KH 708; N, P, W

Campanulaceae
Lobelia appendiculata A. DC., KH 521; N, A, C
Lobelia cardinalis L., KH 551; N, P, W
Lobelia puberula Michx., KH 599; N, A, W
Triodanis perfoliata (L.) Nieuw., SH 10974; N, A, C
Wahlenbergia marginata (Thunb.) A. DC., SH 10799; N, A, C

Cannabaceae
Celtis tenuifolia Nutt., AG s.n.; N, P, C

Caprifoliaceae
Lonicera japonica Thunb., SH 10770; I, P, C
Lonicera sempervirens L., AG 647; N, P, C
Symphoricarpos orbiculata Moench, KH 658 a; N, P, W
Viburnum dentatum L., KH 418; N, P, W
Viburnum prunifolium L., KH 849; N, P, W
Viburnum rufidulum Raf., KH 671; N, P, C

Caryophyllaceae
Cerastium glomeratum Thuillier, KH 682; I, A, C

Convolvulaceae
Ipomoea cordatotriloba Dennst., SH 10811; N, P, W
Ipomoea pandurata (L.) Mey., KH 449; N, P, W

Cornaceae
Cornus florida L., SH 10714; N, P, C

Cyrillaceae
Cyrilla racemiflora L., KH 617; N, P, W

Droseraceae
Drosera capillaris Poir., AG 622; N, A, C

Ericaceae
Lyonia mariana (L.) D. Don, AG 646; N, P, W
Monotropa uniflora L., AG 508; N, P, C
Rhododendron canescens (Michx.) Sweet, AG 653; N, P, C (Fig. 4)
Vaccinium arboreum Marsh., KH 436; N, P, C
Vaccinium elliottii Chapm., KH 669; N, P, C

Euphorbiaceae
Chamaesyce cordifolia (Elliott) Small, KH 410; N, A, W
Cnidoscolus texanus (Müll. Arg.) Small, KH 876 a; N, P, W
Croton capitatus Michx., KH 446; N, A, W
Croton michauxii G.L. Webster, KH 768; N, A, W
Phyllanthus urinania L., LB; I, A, W
Sebastiana fruticosa (Bartr.) Fern., KH 429; N, P, W
Stillingia sylvatica L., KH 649; N, P, C
Tragia smallii Shinners, KH 770; N, P, W
**Triadica sebifera* (L.) Small, AG 545; I, P, W

Fabaceae
Albizia julibrissin Durazz., KH 725; I, P, W
Baptisia spp., (more material needed to make a more accurate identification), SH 10657; N, P, C
Baptisia nuttalliana Small, KH 885; N, P, C
Cercis canadensis L., KH 771; N, P, C
Chamaecrista fasciculata (Michx.) Greene, KH 435 b; N, A, W
Crotalaria sagittalis L., SH 10771; N, P, W
Dalea purpurea Vent., KH 853; N, P, W
Dioclea multiflora (T. & G.) Mohr, SH 10819; N, P, W
Erythrina herbacea L., SH 10798; N, P, C
Lespedeza hirta (L.) Hornem., KH 884; N, P, W
Mimosa hystricina (Small ex Britton & Rose) B.L.Turner. KH 716; N, P, W
Mimosa nuttallii (DC. ex Britton & Rose) B.L. Turner, SH 10740; N, P, W
Rhynchosia latifolia Nutt. ex Torr. & A. Gray, SH 10712; N, P, W
Sesbania drummondii (Rydb.) Cory, KH s.n.; N, P, W
Sesbania herbacea (Mill.) McVaugh, KH 475; N, A, W
Strophostyles umbellata (Muhl. ex Willd.) Britton, KH 437; N, A, W
Stylosanthes biflora (L.) B.S.P., KH 721; N, P, W
Tephrosia virginiana (L.) Pers., SH 10805; N, P, C

Fagaceae
Castanea pumila (L.) Mill., KH 517; N, P, C
Fagus grandifolia Ehrh., KH 531; N, P, C
Quercus alba L., KH 426; N, P, C
Quercus laurifolia Michx., KH 581; N, P, C
Quercus lyrata Walter, KH 471; N, P, C
Quercus macrocarpa Michx., KH 407; N, P, C
Quercus margarettae (Ashe) Small, SH 10770; N, P, C
Quercus marilandica Münchh., KH 438; N, P, C
Quercus michauxii Nutt., KH 794; N, P, C
Quercus nigra L., KH 482; N, P, C
Quercus phellos L., KH 742; N, P, C
Quercus stellata Wangenh., KH 874; N, P, C

Gelsemiaceae
Gelsemium sempervirens (L.) W.T. Aiton, KH 665; N, P, C

Gentianaceae
Sabatia campestris Nutt., KH 845; N, P, W (Fig. 5)

Haloragaceae
Myriophyllum aquaticum (Vell.) Verdc., AG 657; I, P, W
Proserpinaca palustris L., AG 562; N, P, W

Hamamalidaceae
Hamamelis virginiana L., AG 562; N, P, C
Hamamelis vernalis Sarg., KH 414; N, *P, C*

Hypericaceae
Hypericum galioides Lam., SH 10663; N, P, W

Hypericum hypericoides (L.) Crantz, SH 10685; N, P, W
Hypericum frondosum Michx., SH 10760; N, P, W

Iteaceae
Itea virginica L., KH 468; N, P, W

Juglandaceae
Carya aquatica (Michx. f.) Nutt., KH 437; N, P, C
Carya cordiformis (Wang.) K. Koch, SH 10795; N, P, C
Carya laciniosa (Michx. f.) G. Don, SH 10727; N, P, C
Carya texana Buckley, KH 587; N, P, C
Carya tomentosa (L.) Nutt., KH 451 ; N, P, C

Lamiaceae
Callicarpa americana L., KH 723; N, P, W
Monarda punctata L., KH 445; N, A, W
Salvia coccinea P.J. Buchoz ex Etlinger, LB; N, P, W
Salvia lyrata L., AG 627; N, P, C
Scutellaria cardiophylla Engelm. & A. Gray, SH 10715; N, P, W
Scutellaria parvula Michx. var. *parvula*, AG 628; N, P, C
Scutellaria ovata Hill, KH 728; N, P, W

Lauraceae
Persea borbonia (L.) Spreng., KH 664; N, P, W
Sassafras albidum (Nutt.) Nees, SH 10797; N, P, C

Lentibulariaceae
Utricularia radiata Small, KH 668; N, A, C

Linaceae
Linum medium (Planch.) Britton, SH 10774; N, P, C

Magnoliaceae
Magnolia grandiflora L., SH 10818; N, P, C
Magnolia virginiana L., SH 10855; N, P, C

Moraceae
Morus rubra L., SH 10817; N, P, C

Myricaceae
Myrica cerifera L, AG 634; N, P, C
Morella caroliniensis (Mill.) Small, N. P, C

Myrsinaceae
Anagallis arvensis L., SH 10858; I, A, C

Nyssaceae
Nyssa aquatica L., KH 484; N, P, C
Nyssa sylvatica Marshall., SH 10889; N, P, C

Oleaceae
Chionanthus virginicus L., AG 624; N, P, C
Fraxinus americana L., KH 532; N, P, C
Fraxinus caroliniana Mill, SH 10816; N, P, C
Fraxinus pennsylvanica Marsh., SH 10767; N, P, C
Ligustrum sinense Lour., KH 690; I, P, W

Onagraceae
Ludwigia decurrens Walter, KH 613; N, P, W

Orobanchaceae
Epifagus virginiana (L.) W. Bartram, DK 2524; N, P, W

Oxalidaceae
Oxalis stricta L., KH 671; N, P, C
Oxalis corniculata L., SH 10663; N, A, C

Passifloraceae
Passiflora incarnata L., KH 854; N, P, W

Phytolaccaceae
Phytolacca americana L., SH 10827; N, A, W

Plantaginaceae
Mecardonia procumbens (Mill.) Small, AG 659; N, P, W
Plantago aristata Michx., SH 10737; N, A, C
Plantago rhodosperma Decne., SH 10728; N, A, C
Scoparia dulcis L., KH 568; I, A, W

Platanaceae
Platanus occidentalis L., AG 579; N, P, C

Polygalaceae
Polygala incarnata L., KH 714 a; N, A, W
Polygala polygama Walter, SH 10663; N, P, C
Polygala sanguinea L., SH 10742; N, A, W

Polygonaceae
Brunnichia ovata (Walter) Shinners, KH 536; N, P, C
Polygonum hydropiperoides Michx., KH 458; N, P, W
Polygonum virginianum L., KH 523; N, A, W
Rumex hastatulus Baldw., SH 10812; N, A, C

Ranunculaceae
Clematis crispa L., SH 10893; N, P, C
Clematis pitcheri Torr. & A. Gray, SH 10726; N, P, W
Clematis reticulata Walter, KH 775; N, P, W
Ranunculus hispidus Michx., AG 656; N, P, C
Ranunculus pusillus Poir., AG 667; N, A, C

Rhamnaceae
Berchemia scandens (Hill) K. Koch, KH 766; N, P, C
Ceanothus americanus L., SH 10810; N, P, C
Frangula caroliniana (Walter) A. Gray, KH 778; N, P, C

Rosaceae
Crataegus marshallii Eggl., KH 844 a; N, P, C
Crataegus spathulata Michx., SH 10759; N, P, C
Duchesnea indica (Andrews) Focke, KH 528; I, P, C
Geum canadense Jacq., SH 10753; N, P, C
Prunus angustifolia Marshall., KH 693; N, P, C
Prunus umbellata Elliott, KH 848; N, P, C
Pyrus calleryana Decn., LB; I, P, C
Rubus aboriginum Rydb., AG 620; N, P, C
Rubus trivialis L.H. Bailey, AG 619; N, P, C
Spiraea cantoniensis Lour., LB; I, P, C

Rubiaceae
Cephalanthus occidentalis L., KH 856; N, P, W
Diodia virginiana L., KH 858; N, P, W
Galium obtusum Bigelow, SH 10703; N, P, C
Galium tinctorium (L.) Scop., AG 666; I, P, W
Houstonia micrantha (Shinners) Terrell, KH 690; N, A, C
Houstonia pusilla Schoepf, AG 620; N, A, C
Mitchella repens L., KH 510; N, P, C

Rutaceae
Zanthoxylum clava-herculis L., KH 651; N, P, C

Salicaceae
Populus deltoides Bartram ex Marshall., KH 847; N, P, C

Sapindaceae
Acer rubrum L., KH 579; N, P, C
Acer saccharum Marshall., KH 839; N, P, C
Aesculus pavia L., SH 10723; N, P, C

Sapotaceae
Sideroxylon lanuginosum Michx., KH 683; N, P, W

Saururaceae
Saururus cernuus L., SH 10682; N, P, W

Solanaceae
Solanum carolinense L., KH 781; N, P, W

Styrax grandifolius Ait., KH; N, P, C

Styracaceae
Halesia diptera Ellis, KH 467; N, P, C

Symplocaceae
Symplocos tinctoria (L.) L'Her., KH 626; N, P, C

Theophrastaceae
Samolus valerandi L., SH 10841; N, P, W

Tetrachondraceae
Polypremum procumbens L., KH 418; N, A, W

Ulmaceae
Planera aquatica J.F. Gmel., KH 474; N, P, C
Ulmus alata Michx., KH 863; N, P, C
Ulmus americana L., AG 514; N, P, C

Urticaceae
Pilea pumila (L.) A. Gray, KH 878; N, A, W

Verbenaceae
Glandularia canadensis (L.) Nutt., KH 670; N, P, W
Stylodon carneus (Medic.) Moldenke, LB; N, P, W
Verbena rigida Spreng., SH s.n.; I, P, W

Violaceae
Viola missouriensis Greene, KH 663; N, P, C
Viola primulifolia L., KH 678; N, P, C

Vitaceae
Parthenocissus quinquefolia (L.) Planch., KH s.n.; N, P, W
Vitis aestivalis Michx., KH 843; N, P, C
Vitis cinerea (Engelm.) Engelm. ex Millard var. *cinerea*, KH 736; N, P, C
Vitis rotundifolia Michx., KH 737; N, P, C
Vitis vulpina L., SH 10719; N, P, C

ACKNOWLEDGMENTS

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ANNOUNCEMENT

Report from a New Botanical Nomenclature Course

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A Botanical Nomenclature Course workshop was jointly organized by the Botanical Survey of India (BSI) and ENVIS Centre on Floral Diversity-BSI in Kolkata from January 11–13, 2013 at the Hotel Presidency Inn Pvt. Ltd., Kolkata. This workshop was the first of its kind organized in India. Dr. Kanchi N. Gandhi (Senior Nomenclatural Registrar, Harvard University Herbaria, USA) was the Course Director; Dr. Paramjit Singh (Director, BSI) was the Course Convener; and Dr. P. Lakshminarasimhan (Scientist 'D', BSI) was the Course Coordinator. The BSI botanist late Dr. Mithilesh K. Pathak was helpful in organizing the workshop. There were 96 total participants, 51 from BSI and 45 from outside BSI. The participants included Research Fellows/Associates from BSI, faculties from universities/colleges, scientists from research institutes, one Project officer from Foundation for Ecological Security (Gujarat), and a Deputy Director of Public Instruction (UGC), Education Directorate, Govt. of West Bengal, Kolkata.

On the inaugural day, Dr. Lakshminarasimhan welcomed the gathering and outlined the course program. His talk was followed by two lectures: 1) The importance of Botanical Nomenclature by Prof. P.K. Mukherjee (Calcutta University) and 2) Taxonomy and Global Strategy for Plant Conservation by Dr. D.K. Singh (Scientist 'F', BSI). Two lectures were given by Mr. R.L. Mitra (Scientist (Retd.), BSI): 1) Scientific Names of Plants—Some Facts and Misconceptions (on January 11) and 2) Type Concept and Nomenclatural Problems (on January 12). Dr. Gandhi's lectures were spread over the three days, and he covered the following topics:

1) An historical overview of the botanical nomenclature from Linnaeus to the Melbourne Code
2) Review of the physical structure of the Melbourne Code
3) Preamble, ranks and names of taxa, and effective publication (Articles 1–28)
4) Validity of names, Part I (Articles 32–45)
5) Validity of names, Part II
6) Authorship citation (Articles 46–50)
7) Rejection of names (Articles 51-60)
8) Anamorphic fungal and hybrid names

In the concluding function on January 13, there was a lecture by Dr. Paramjit Singh on "Floristic Diversity in India: An overview." After his talk, certificates were distributed to all the participants. Valedictory remarks were delivered by: Dr. R.K. Chakraverty (Additional Director (Retd.), BSI), Dr. Kanchi N. Gandhi, Dr. P. Lakshminarasimhan, Prof. G.G. Maity (Retd; Kalyani University), Prof. N.D. Paria (Calcutta University), Dr. D.K. Singh, and Dr. Paramjit Singh.



ELEOCHARIS MICROFORMIS (CYPERACEAE): REDISCOVERED IN NORTH AMERICA FROM THE EDWARDS PLATEAU AND TRANS-PECOS REGIONS OF TEXAS

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ABSTRACT

Eleocharis microformis Buckley, Buckley's Dwarf Spike-rush, has been rediscovered from the Edwards Plateau and Trans-Pecos regions of Texas. A careful examination of recent collections as well as the few known historical specimens confirms it to be distinct from *E. geniculata* (L.) Roem. & Schult. and *E. atropurpuea* (Retz.) J. Presl & C. Presl. Henry K. Svenson placed *E. microformis* in synonymy under *E. geniculata* in 1939, and the name has been generally overlooked ever since. The evidence presented here supports the resurrection of Buckley's original epithet as a distinct species.

RESUMEN

Eleocharis microformis Buckley, Buckley's Dwarf Spike-rush, ha sido redescubierto en la regiones de Edwards Plateau y Trans Pecos de Texas. Un examen cuidadoso de colecciones recientes así como los pocos especimenes históricos conocidos confirman que es diferente de *E. geniculata* (L.) Roem. & Schult. y *E. atropurpuea* (Retz.) J. Presl & C. Presl. H.K. Svenson colocó *E. microformis* en la sinonimia de *E. geniculata* en 1939, y el nombre ha sido generalmente omitido desde entonces. La prueba presentada aquí soporta la resurrección del epíteto original de Buckley como una especie distinta.

INTRODUCTION

Eleocharis microformis Buckley, in subgenus *Eleocharis* sect. *Eleogenus*, subser. *Rigidae* (González-Elizondo & Peterson 1997), was described by Samuel Bostford Buckley in 1862 (Buckley 1862) from a specimen collected in "northern Texas" (*Buckley s.n.*, PH). Later that year Asa Gray remarked that *E. microformis* "[a hybrid name] is near *E. intermedia*, Schultes" (Gray 1862). Buckley responded by saying *E. microformis* "is probably a good species" (Buckley 1870). Svenson (1939) reduced *E. microformis* to a synonym under *E. geniculata* (L.) Roemer & J.A. Schultes and the name has been overlooked in taxonomic treatments for the last 74 years. Although described from Texas, *E. microformis* has never been mentioned either as a species or as a synonym in any Texas or North American flora or checklist (Gould 1962; Correll & Johnston 1970; Correll & Correll 1972; Godfrey & Wooten 1979; Hatch et al. 1990; Kartesz 1994; Jones et al. 1997, Diggs et al. 1999; Kartesz & Meacham 1999; Smith et al. 2003). Hooker and Jackson (1895), in the first volume of *Index Kewensis*, following Gray's comment, gave *Eleocharis intermedia* Schult. as a synonym of *E. microformis*. *Eleocharis intermedia* is a species in section *Eleocharis*, known from the northeastern United States, with golden-brown, compressed-trigonous achenes with narrowly pyramidal tubercles. In contrast, *E. microformis* is in section *Eleogenus* with shiny black, biconvex achenes with depressed-umbonate tubercles.

Taxonomic History

The epitaphs *Eleocharis geniculata, E. caribaea* (Rottb.) S.F.Blake, *E. microformis, and E. elegans* Roem. & Schult. have been confused for decades (Svenson 1929, 1937, 1939, 1957). Henry Knute Svenson, who for decades worked on the genus *Eleocharis*, recognized *E. microformis* as a distinct species in the first part of his "Monographic studies in the genus *Eleocharis*" (Svenson 1929). Of the collections from six different locations that Svenson examined, he annotated each one as *E. microformis* at least once and some a second time from 1925 to 1937. From 1948 to 1967 he re-annotated most of these specimens as *E. caribaea*, which he later (Svenson 1939)

treated as a synonym of *E. geniculata*. He stated, "The dwarf round-headed *E. microformis* from Texas with achenes 0.7–0.9 mm long, often confused with *E. atropururea*, I now believe to be a small extreme of *E. geniculata* (*E. caribaea*), similar to specimens from Nicaragua (*Maxon, Harvey, & Valentine 7291*, NY) and from Honduras (*Schipp No. 913 & Standley No. 56671*, NY)" (Svenson 1939). Upon recent examination by O'Kennon, the collections from Honduras appeared to be smallish but otherwise typical *E. geniculata*. The collection from Nicaragua was a short *E. geniculata* with smaller than usual achenes (0.7–0.8 mm long), but had none of the characteristics of *E. microformis*. Svenson re-annotated a Reverchon collection (*1672*, TEX) of *E. microformis* from Blanco County, Texas as *E. caribaea* with the comment that it was a "form with small heads and small achenes ..."

Of the five taxa within subser. *Ridigae*, only *E. atropurpurea* (Retz.) J. Presl & C. Presl and *E. geniculata* are widespread in North America (González-Elizondo & Peterson 1997,). *Eleocharis bahamensis* Boeckeler and *E. sintenisii* Boeckeler are endemic to the Bahaman islands and Puerto Rico, respectively, and *E. microformis* is endemic to Texas. Upon cursory examination, *Eleocharis microformis* resembles both *E. atropurpurea* and *E. geniculata*. Herbarium specimens of *E. geniculata* and *E. atropurpurea* were examined from the following herbaria: BRIT, SMU, TEX-LL, GH, MO, US, NY, and TAES. Twenty-one specimens (including duplicates) were identified matching Buckley's description of *E. microformis*. Upon examination of specimens of *E. geniculata, E. atropurpurea*, and *E. microformis*, it became immediately obvious to us that *E. microformis* was distinct and supported the resurrection of Buckley's original name.

Eleocharis atropurpurea is easily distinguished from the other species by its small (0.4–0.5 mm) black achenes with a small subconic tubercle usually less than ¼ as wide as the achenal body, generally with bright white bristles shorter than to equaling the achenal body (Table 1). *Eleocharis microformis* is distinguished from *E. geniculata* by its smaller achenes (less than 0.65 mm vs. greater than 0.7 mm) with a larger tubercle (½ as broad as the achene vs. ⅓ as broad), fewer scales per spikelet (generally fewer than 20 vs. more than 28), shorter scales (1 mm vs. 1.5–2 mm), shorter bristles (shorter than or equaling achene length vs. longer than achene), thinner culms (0.2–0.3 mm vs. 0.5–1.0 mm), and arching to ascending habit (vs. erect to ascending) (Table 1, Fig. 1).

Eleocharis microformis and *E. geniculata* are sympatric on the Edwards Plateau, and we have observed them growing side by side on four sites. Although there are minor variations in size within each species and occasional overlaps in size between these species, no recognizable intermediates have been observed. *Eleocharis microformis* also occurs on the same sites with *E. atropupurea*, a diminutive species with which it is often confused in the field but is distinguished by its smaller tubercle and achenes (see key and Figures 1 & 2 herein).

Distribution

The first known collections of what Buckley later called *Eleocharis microformis* were made in July of 1852 by Charles Wright (*1930, 1932, 1961* GH) while he "was on the Pecos on his way back to San Antonio (Shaw 1987)." Label information for no. 1930 indicates "Howard Creek, Texas" on 4 July. Howard Creek meets the Pecos River in northwestern Val Verde County, about 40 km (25 mi) downriver from Live Oak Creek where Wright made collections two days prior (Gray 1852–1853). This is likely the "Howard Creek" cited on the specimen. Numbers 1932 and 1961 lack locality information but are probably in the vicinity (Svenson 1929).

Eleocharis microformis was next found by Buckley in June 1861 (*s.n.*, PH), and described by him in 1862. In the protologue of his collection, Buckley did not include an exact location for that 1861 collection other than "northern Texas." According to Dorr and Nixon (1985), Buckley worked as a geologist and naturalist for the Geological Survey of Texas in June 1861, and he traveled from Austin to work on the survey of Navarro County about 250 km north of Austin. This apparently was his northern-most excursion in Texas and the specimen was likely collected somewhere along his route.

Reverchon collected *E. microformis* in 1885 from "swamps" in Blanco Co. (*1672*, GH, LL, MO, NY, US; *3594*, MO, NY, US), and from "Texas" (*s.n.* GH). Reverchon's collection number *1673* of *E. geniculata* (*Reverchon 1673*, MO) was from the banks of the Pedernales River in Blanco Co. It is likely that his "swamps" are also

TABLE 1. Character differences between *Eleocharis microformis* and *E. geniculata*. Measurements of the achenes are for the achenal body itself not including the tubercle. Measurements indicated in the Flora of North America treatment for the genus *Eleocharis* (Smith et al. 2003) were likely inclusive of *E. microformis* specimens. The measurements indicated below are revised to recognize *E. microformis* as a distinct species.

Character	*Eleocharis microformis*	*Eleocharis geniculata*
1. achene length	0.5–0.65mm long	0.7–0.9(–1.1) mm
2. tubercle width relative to achene	fully ½ as broad	1/3 as broad
3. spikelet size	2–3(–4) mm long	(3–)4–7 mm long
4. spikelet shape	ellipsoid to ovoid	globose to ovoid
5. number of spikelet scales	10–20(–26)	28–50
6. scale color	brownish-orange to reddish-brown with conspicuous yellowish-green keel	stramineous-buffy with inconspicuous tan to pale-greenish keel
7. scale length	1 mm long	1.5–2 mm long
8. bristle length	generally shorter than or equal to achene	generally longer than or equal to achene
9. number of bristles	4–6	6–8 or lacking
10. culm length	(1–)3–6(–9) cm	(5–)10–25(–45) cm
11. culm thickness	0.2–0.3 mm	0.5–1.0 mm
12. culms arching or erect	arching to ascending	generally erect to ascending

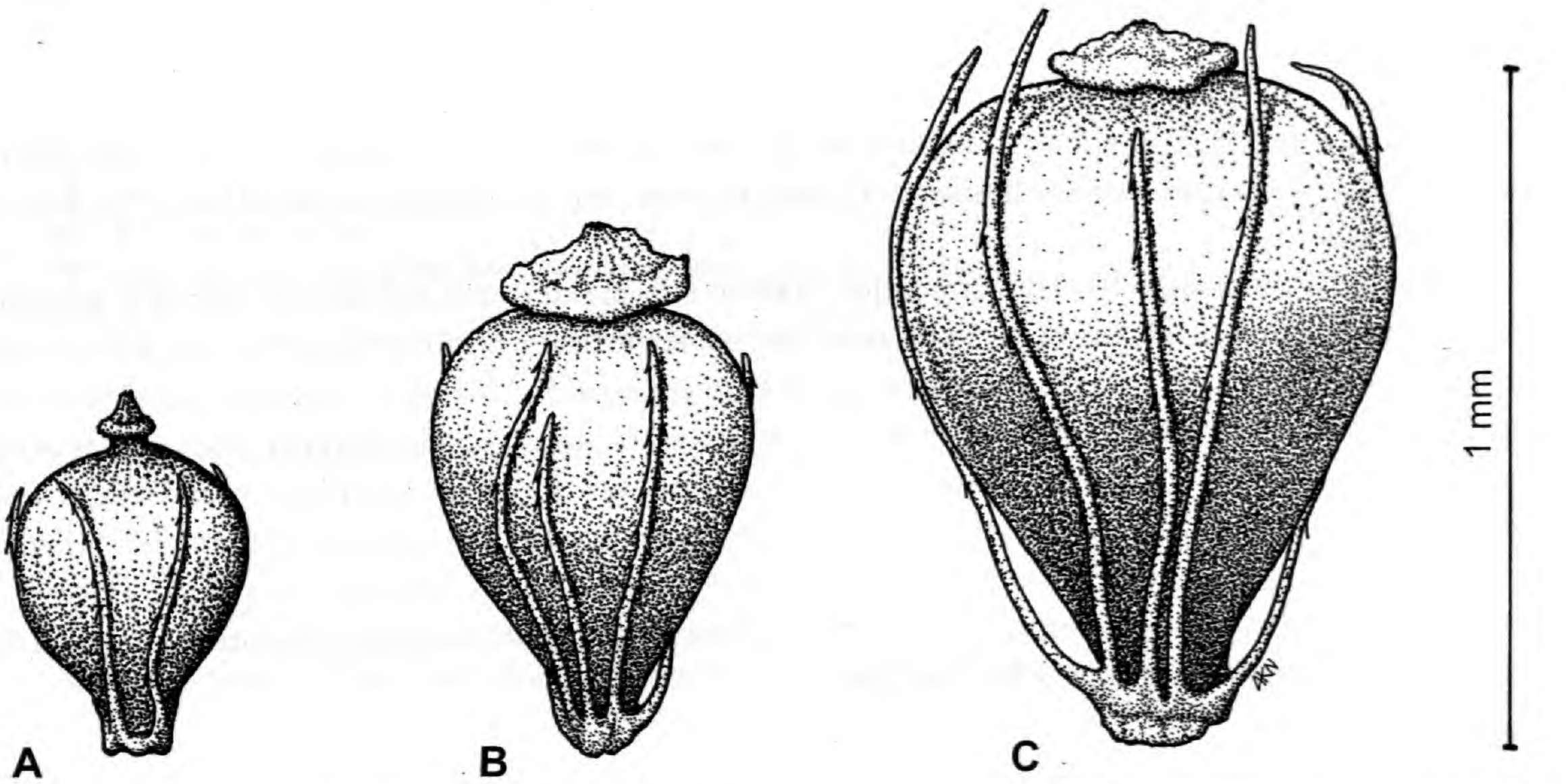


FIG. 1. Line drawings of achenes of three closely related taxa: A. *Eleocharis atropurpurea* (*O'Kennon 10663*). B. *Eleocharis microformis* (*O'Kennon 10171*). C. *Eleocharis geniculata* (*O'Kennon 10710*). Illustration by Amanda Neill.

somewhere along the Pedernales River. Palmer also collected along the Pedernales River in Blanco Co. in 1928 (*Palmer 33921*, MO). In 1892, E.N. Planks collected the plant in Lampasas Co. (*s.n.*, NY), but a location was not indicated. In 1894, Arthur Heller (*1851*, GH, MO, SMU, US), collected plants "about Kerrville" in Kerr County, and B.C. Tharp collected two specimens in Travis Co. near Lake Austin in 1922 (*2128*, *2129*, US). Victor L. Cory collected *E. microformis* in Reagan Co. south of Big Lake in 1929 (*s.n.*, GH) and 1939 (*32765*, TAES), and in 1934 from Edwards Co. southeast of Rocksprings (*9816*, GH).

Since Wright's first collection of *E. microformis* in 1852 until 1988 (136 years), there had been only 15 collections made, likely from only nine locations. Richard Worthington made a collection in the Indio Mountains in Hudspeth Co. in 1988 (*Worthington 17456*, UTEP) and in the Franklin Mountains in El Paso Co. in 1993 (*Worthington 22241*, UTEP). Eight additional sites were located in Gillespie, Kerr, Llano, Mason, and Uvalde counties by O'Kennon in 1991 and 1992 during research on the flora of the Edwards Plateau of central Texas.



Fig. 2. Photographs of achenes of three closely related taxa. From left to right: *Eleocharis atropurpurea* (*O'Kennon 10663*). *Eleocharis microformis* (*O'Kennon 10171*). *Eleocharis geniculata* (*O'Kennon 10710*).

Estes, Proctor, and Benesh found an additional site of *E. microformis* in 1995 in Bexar Co. (*BUL0856*, BRIT). This makes a total of approximately 18 sites in 14 counties, since one of O'Kennon's sites is likely the same as Heller's 1894 site.

A field survey was made by O'Kennon in July 2009 to relocate all recent and historic sites of *E. microformis*. Plants were found at only five of the 14 locations known at the time (the site in Bexar Co. was not searched due to restricted access, the sites in Hudspeth and El Paso counties and Wright's "Howard Creek" were unknown to us at the time and have not been searched) with a total of only 37 plants observed. The only historical site relocated was south of Kerrville along Turkey Creek near Hwy 16 which could have been Heller's 1894 location "about Kerrville". The other four locations were at sites located by O'Kennon in 1991 and 1992 (Fig. 3). An extensive search for the plants was made by O'Kennon in Blanco County, but none were found. Places that could have been Reverchon's "Swamps" were not found. Plants were never found near Lake Austin, south of Big Lake, or in Edwards Co. southeast of Rocksprings.

Conservation Status

There are only 18 known locations for *Eleocharis microformis* in the world in 14 Texas counties. As of 2009, only 5 of the 14 sites surveyed had extant populations. Seven of the historic collection locations have not been seen in over 70 years and may be extirpated. With so few sites, this Texas endemic is rare and perhaps warrants conservation status.

KEY TO NORTH AMERICAN *ELEOCHARIS* (SUBGENUS *ELEOCHARIS* SECT. *ELEOGENUS* SUBSERIES RIGIDAE)

NOTE, IN THIS KEY, THE ACHENE IS THE ACHENAL BODY NOT INCLUDING THE TUBERCULE

1. Distal leaf sheaths often disintegrating, thinly membranous-transluscent, prominently inflated and wrinkled; achenes stramineous to green or dark brown; creeping rhizomes present _____ (Subser. *Ocreatae*) **Eleocharis flavescens**
1. Distal leaf sheaths evident, rarely disintegrating, firmly membranous to papery, not prominently inflated or conspicuously wrinkled; achenes bright shiny black; creeping rhizomes absent _____ (Subser. *Rigidae*)
   2. Achenes 0.4–0.5 mm long; tubercle subconic, ¼ or less as wide as achene _____ **Eleocharis atropurpurea**
   2. Achenes 0.5–1.1 mm long; tubercle depressed, more than ¼ as wide as achene.
      3. Achenes 0.7–0.9(–1.1) mm long; tubercle depressed, only ⅓ as broad as the achene; bristles (0–)6–8, brownish, generally exceeding the achene or absent; spikelets globose to ovoid, (3–)4–7 mm long, 28–50-flowered; spikelet scales firm, stramineous-buffy with an inconspicuous tan midrib, 1.5–2 mm long; plants generally strictly erect to ascending, culms (5–)10–25(–45) cm high, 0.5–1 mm thick (widespread in warm or tropical regions) _____ **Eleocharis geniculata**

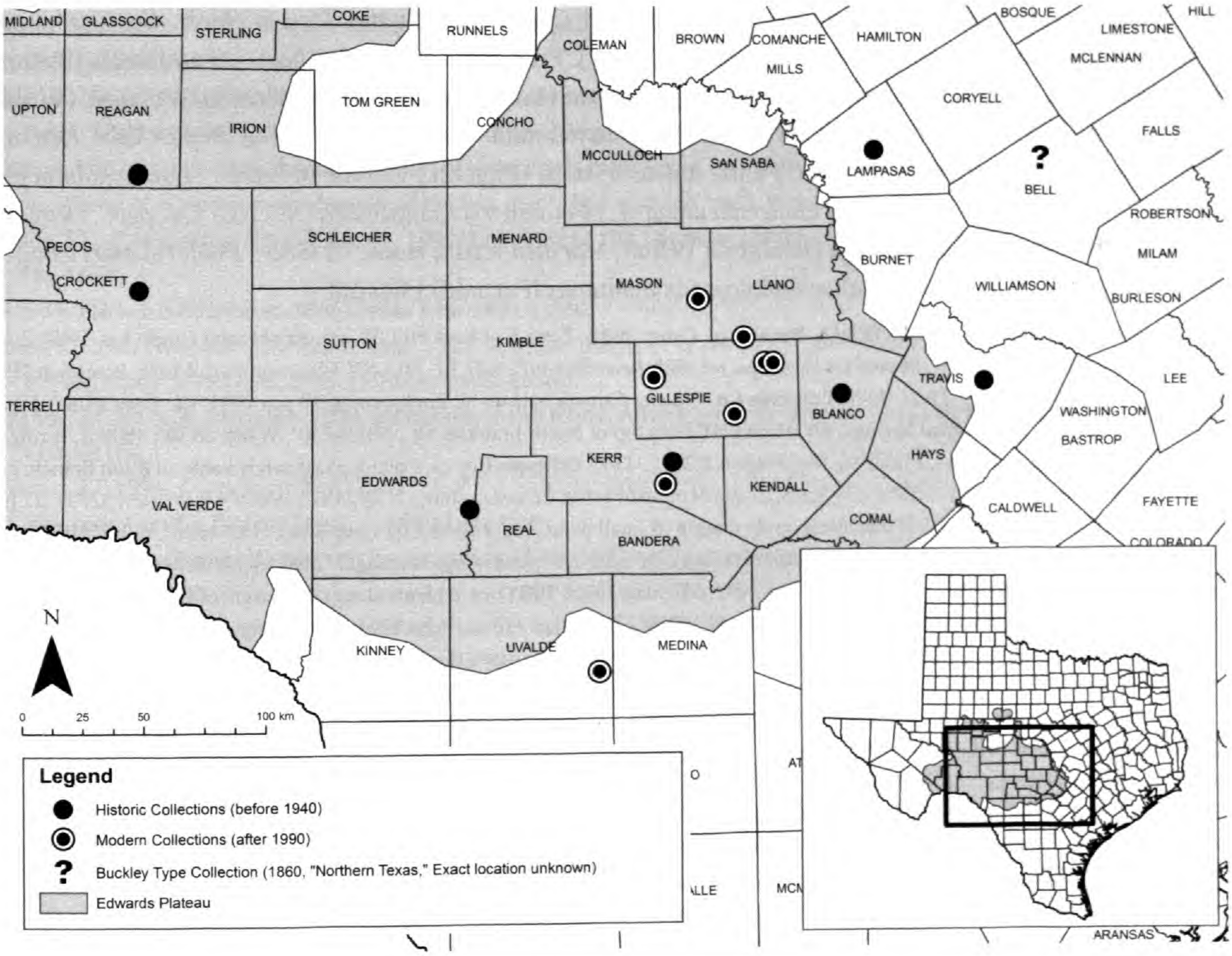


Fig. 3. Known distribution of *Eleocharis microformis* in Texas.

3. Achenes 0.50–0.65 mm long; tubercle depressed-umbonate, at least ½ as broad as the achene; bristles 4–6, light-brown to whitish, generally shorter than the achene; spikelets ellipsoid to ovoid, 2–3(–4) mm long, 10–20(–26)-flowered; spikelet scales thin, brownish-orange to reddish-brown with a conspicuous greenish-yellow midrib, 1 mm long; plants dwarf, arching to ascending, culms (1–)3–6(–9) cm high, 0.2–0.3 mm thick (central and west Texas) **Eleocharis microformis**

Eleocharis microformis Buckley, Proc. Acad. Nat. Sci. Philadelphia 14:5–10. 1862. Type: U.S.A. Texas: northern Texas, Jun 1861, *Buckley* s.n. (lectotype: PH!)

Plants annual, densely tufted, without creeping rhizomes. **Culms** arching to ascending, setaceous, lightly sulcate, (1–)3–6(–9) cm long, 0.2–0.3 mm thick. **Leaves:** distal leaf sheaths firm, distally tightly sheathing, apex acute. **Spikelets** ellipsoid to ovoid, acute, 10–20(–26)-flowered, 2–3(–4) mm long; floral scales obtuse, often rufescent, with a greenish-yellow midrib and light brown hyaline margins. **Flowers:** perianth bristles 4–6, light-brown to whitish, generally shorter than the achene, retrorsely barbed (120×); styles bifid. **Achenes** broadly obovoid-pyriform, shiny black when ripe, biconvex, 0.5–0.65 × 0.4–0.5 mm, not constricted proximal to tubercle, surface minutely pitted at 40×. **Tubercles** white, depressed-umbonate, at least ½ as broad as the achene.

Fruiting Jun–Aug. Wet areas including pond margins, creeks, riverbanks, and ephemeral swales in a variety of soil substrates including sand, clay, and granite. Specimens examined with known site locations are from central and west Texas. The exact location of the type collection protologue from "northern Texas" is unknown; elevation 258–1455 m.

Associated plants include: *Ammannia coccinea* Rottb., *Ammannia robusta* Heer & Regel, *Lysimachia mini-*

ma (L.) U.Manns & Anderb., *Centella erecta* (L.f.) Fernald, *Cyperus acuminatus* Torr. & Hook., *Cyperus haspan* L., *Cyperus squarrosus* L., *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl, *Eleocharis coloradoensis* (Britton) Gilly, *Eleocharis engelmannii* Steud., *Eleocharis geniculata* (L.) Roem. & Schult., *Eleocharis obtusa* (Willd.) Schult., *Fimbristylis autumnalis* Roem. & Schult., *Fimbristylis vahlii* (Lam.) Link, *Fuirena simplex* Vahl, *Heteranthera limosa* Willd., *Isoetes lithophila* N. Pfeiff., *Juncus texanus* (Engelm.) Coville in Small, *Limnosciadium pinnatum* (DC.) Mathias & Constance, *Lindernia dubia* (L.) Pennell var. *anagallidea* (Michx.) Cooperr., *Hemicarpha micrantha* (Vahl) Pax, *Ludwigia glandulosa* Walter, *Marsilea vestita* Hook. & Grev., *Pilularia americana* A. Braun, *Rotala ramosior* Koehne, *Schoenoplectus saximontanus* (Fernald) J.Raynal.

Voucher specimens examined: **U.S.A. TEXAS. Bexar Co.:** Camp Bullis, Pond E of Buck Hill, W branch of Lewis Creek, Jun 1995, *Estes, Procter, & Benesh BUL0856* (BRIT). **Blanco Co.:** swamps, Jul 1885, *Reverchon 1672* (GH, LL, MO, NY, US); swamps, Jul 1885, *Reverchon 3594*; Pedernales River, 1928, *Palmer 33921* (MO). **Edwards Co.:** Nueces Canyon 14¼ mi SE Rocksprings, 10 Sep 1934, *V.L. Cory 9816* (GH). **El Paso Co.:** 0.3 air mi NW of Indian Springs, 1.8 air mi ENE from top of North Franklin Mt., N31°54'30", W106°28'30", 4800 ft, spring in canyon bottom, granitic substrate, 3 Jul 1993, *Worthington 22241* (UTEP). **Gillespie Co.:** ca. 9 plants along sandy banks of Knott Branch, 230 m E of State Highway 16 on Old Willow City Road, 21 km N of Main Street Fredericksburg, N30°24'47", W098°44'03", elev. 527 m, 22 Jun 1992, *O'Kennon 10675* (BRIT); ca. 5 plants along sandy margin of small pond, Old Willow City Loop Road, N30°24'46", W098°41'53", elev. 563 m, 30 Jul 1992, *O'Kennon 10704* (BRIT); ca. 8 plants along clay margin of pond along Threadgill Creek on McGinley Ranch, 9 km N of Harper, N30°21'50", W099°13'05", elev. 604 m, 1 Aug 1992, *O'Kennon 10706* (BRIT); ca. 6 plants along clay margin of Threadgill Creek along FM 783 at McGinley Ranch, 9 km N of Harper, N30°21'44", W099°13'09", elev. 610 m, 31 Jul 1992, *R.J. O'Kennon 10707* (BRIT); ca. 6 plants along sandy wet area along banks of the Pedernales River below bridge on State Hwy 16, 5.8 km S of Fredericksburg, N30°13'13", W098°52'09", elev. 486 m, 30 Jul 1992, *R.J. O'Kennon 10705* (BRIT). **Hudspeth Co.:** Indio Mountains, vicinity of Squaw Spring, N30°47'40", W105°00'45", 4200 ft, 18 Sep 1988, *Worthington 17456* (UTEP). **Kerr Co.:** about Kerrville, 12–19 Jun 1894, *Heller 1851* (GH, MO, SMU, US); 6 plants along margin of Turkey Creek by crossing of Fall Creek Road, N29°57'40.7", W099°10'28.8", elev. 499 m, 30 Jun 1993, *O'Kennon 11696* (BRIT). **Lampasas Co.:** 21 Sep 1892, *Plank s.n.* (NY). **Llano Co.:** Enchanted Rock State Natural Area, ca. 5 plants along sandy margin of Moss Pond, N30°30'33", W098°49'31", elev. 458 m, 10 Oct 1991, *O'Kennon 10171* (BRIT). **Mason Co.:** ca. 5 plants along sandy banks of Hay Branch on FM 152, 8.7 km W of Castell, N30°39'22", W099°01'13", elev. 384 m, 25 Jun 1992, *O'Kennon 10677* (BRIT). **Reagan Co.:** 2 mi S of Big Lake in mud, 24 Aug 1939, *Cory s.n.* (GH); 2.5 mi S of Big Lake, 24 Aug 1939, *Cory 32765* (TAES). **Travis Co.:** silt of Colorado River, Lake Austin, 12 Aug 1922, *Tharp 2128* (TEX, US); *2129* (US). **Uvalde Co.:** margin of pond, Winston-Mize Ranch, N29°13'16", W099°13'36", elev 258 m, 7 May 2005, *O'Kennon 19994* (BRIT). **Val Verde Co.:** Howard Creek, 4 Jul 1852, *Wright 1930* (GH); *Wright 1932* (GH, US); *Wright 1961* (GH, US). **County unknown:** northern Texas, Jun 1861, *Buckley s.n.* (PH); "Texas," no date, *Reverchon s.n.* (GH).

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ANNOUNCEMENT

The 2013 Applications for the Delzie Demaree Travel Award

Applications for the 2013 Delzie Demaree Travel Award should include a letter from the applicant telling how symposium attendance will benefit his/her graduate work and letter of recommendation sent by the major professor. Please send letters of application to: Dr. Donna M.E. Ware, P.O. Box 8795, Herbarium, Biology Department, The College of William and Mary, Williamsburg, Virginia 23185-8795, U.S.A. 1-757-221-2799; Email: ddmware@wm.edu. Applications may be sent to: Barney Lipscomb, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A. 1-817-332-7432; Email: barney@brit.org. The period for receiving applications will end three weeks prior to the date of the symposium if a sufficient number of applications are in hand at that time. Anyone wishing to apply after that date should inquire whether applications are still being accepted before applying. The Systematics Symposium dates for 2013 are 11–12 October 2013.

The Delzie Demaree Travel Award was established in 1988 honoring **Delzie Demaree** who attended 35 out of a possible 36 symposia before he died in 1987. Delzie Demaree was a frontier botanist, explorer, discoverer, and teacher. His teaching career as a botanist began in Arkansas at Hendrix College in 1922. He also taught botany at the University of Arkansas, Navajo Indian School, Yale School of Forestry, Arkansas A&M, and Arkansas State University at Jonesboro where he retired as professor emeritus in 1953. One of the things he enjoyed most as a botanist was assisting students with their field botany research.

VASCULAR FLORA OF SALINE LAKES IN THE SOUTHERN HIGH PLAINS OF TEXAS AND EASTERN NEW MEXICO

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ABSTRACT

Saline lakes and freshwater playas form the principal surface hydrological feature of the High Plains of the Southern Great Plains. Saline lakes number less than 50 and historically functioned as discharge wetlands with relatively consistent water availability due to the presence of one or more springs. Currently, less than ten saline lakes contain functional springs. A survey of vascular plants at six saline lakes in the Southern High Plains of northwest Texas and one in eastern New Mexico during May and September 2009 resulted in a checklist of 49 species representing 16 families and 40 genera. The four families with the most species were Asteraceae (12), Amaranthaceae (8), Cyperaceae (5), and Poaceae (12). Non-native species (*Bromus catharticus*, *Poa compressa*, *Polypogon monspeliensis*, *Sonchus oleraceus*, *Kochia scoparia*, and *Tamarix ramosissima*) accounted for 10% of the total species recorded. Whereas nearly 350 species of vascular plants have been identified in playas in the Southern High Plains, saline lakes contain a fraction of this species richness. The Southern High Plains saline lake flora is regionally unique, containing taxa not found in playas, with species composition that is more similar to temperate desert wetlands of the Intermountain Region and Gulf Coastal Plain of North America.

RESUMEN

Los lagos salinos y las playas de agua dulce forman la principal superficie hidrológica de las High Plains de las Southern Great Plains. El número de lagos salinos es menor de 50 e históricamente funcionaron como humedales de descarga con relativa continuidad en la disponibilidad de agua debido a la presencia de uno o más surgencias. Actualmente, solo menos de diez lagos salados contienen surgencias activas. Se realizó un estudio de las plantas vasculares en seis lagos salinos en las Southern High Plains del noroeste de Texas y uno en el este de Nuevo México durante mayo y septiembre de 2009 que dio como resultado un catálogo de 49 especies que representan a 16 familias y 40 géneros. Las cuatro familias con mayor número de especies fueron Asteraceae (12), Amaranthaceae (8), Cyperaceae (5), y Poaceae (12). Las especies no-nativas (*Bromus catharticus*, *Poa compressa*, *Polypogon monspeliensis*, *Sonchus oleraceus*, *Kochia scoparia*, y *Tamarix ramosissima*) fueron el 10% del total de especies citadas. Mientras que se han Identificado cerca de 350 especies de plantas vasculares en las playas de las Southern High Plains, los lagos salinos contienen una fracción de esta riqueza en especies. La flora de los lagos salinos de las Southern High Plains es única regionalmente, contiene taxa no encontrados en playas, con una composición de especies que es más similar a los humedales de los desiertos templados de la región Intermontana y la llanura costera del golfo de Norte América.

INTRODUCTION

In the High Plains of the western Southern Great Plains, playa wetlands and saline lakes form the predominant hydrological surface features. This is particularly evident in the Southern High Plains (SHP) of northwest Texas and eastern New Mexico. Playas of the SHP have received a tremendous amount of conservation and management focus, primarily stemming from concerns regarding natural and anthropogenic threats to playa functional ecology and structure (Bolen et al. 1989; Haukos & Smith 1994; Luo et al. 1997; Smith 2003; Johnson et al. 2012). Numbering nearly 20,000, playas are shallow, isolated, freshwater, precipitation filled recharge wetlands which have been described as islands of biological diversity in one of the most intensively agricultural-ized regions in North America (Bolen et al. 1989; Haukos & Smith 1994; Johnson et al. 2012). Playas are dy-

namic and biologically productive wetlands that provide critical habitat for migrating, breeding, and wintering waterfowl (Ray et al. 2003; Haukos et al. 2006; Moon & Haukos 2006); migrating (Davis & Smith 1998) and breeding shorebirds (Conway et al. 2005a, b); and wintering sandhill cranes (*Grus canadensis*; Iverson et al. 1985). The playa flora has also been the focus of numerous studies, including checklists (Rowell 1971), field guides (Haukos & Smith 1997), and more detailed analyses of plant community structure as related to soils, playa area, and physical location on the landscape (Smith & Haukos 2002; Haukos & Smith 2004; O'Connell et al. 2012).

In contrast, saline lakes of the SHP are poorly studied, and have received little or no conservation attention. Despite the conservation focus upon playas, saline lakes are arguably the most imperiled wetland ecosystem in the region and have been identified as a High Priority Community within the High Plains Ecoregion (Texas Parks and Wildlife Department 2005). Approximately 1 saline lake exists for every 500 historical playas regionally (Reeves & Temple 1986; Haukos & Smith 1994; Smith 2003), but their numerical rarity makes them, and their associated biota, particularly susceptible to both natural and anthropogenic perturbations.

Saline lakes differ from playas ecologically, geologically, and hydrologically (Reeves & Temple 1986; Osterkamp & Wood 1987; Hall 2001). Saline lakes are generally larger than playas, have saline water chemistry, (>200 g/L of dissolved solids [Osterkamp & Wood 1987; Dockery 1989]), are often underlain by areas of deep Permian salt dissolution (Dockery 1989), and usually are bordered by dunes on their leeward side from deflation (Osterkamp & Wood 1987). Geologically older than playas (~300,000 ybp [Wood 2002]), most regional saline lakes have evidence of human occupation 10,000–12,000 ybp (E. Johnson, unpublished data).These settlements were likely due to the permanence of one or more freshwater springs connected to the Ogallala Aquifer in an environment with otherwise rare surface water. Still considered discharge wetlands, saline lakes currently receive most surface water via direct precipitation and from overland flow, as natural artesian freshwater springs associated with most saline lakes have ceased (or have dramatically reduced) flowing during the last 50 years (Brune 1981). Some evidence suggests that ground water elevation in saline lakes is at least 7–8 m lower than 25–55,000 ybp (Wood 2002). As such, surface water presence (and residence time) operates as an ecological driver of floral and faunal (e.g., bird and insect) community attributes in saline lakes (Conway et al. 2005 a, b; Andrei et al 2008; Conway unpublished data; Saalfeld et al. 2012).

Conservation concerns surrounding saline lakes are multifaceted, but cessation of spring flow causing a reduction in surface water residence time and an increase in salt concentrations are arguably the most pressing. Saline lake hydrology is impacted by interactions among variable hydroperiods, high evapotranspiration rates, unpredictable precipitation patterns, and anthropogenic disturbances (i.e., groundwater pumping; Conway et al. 2005a, b; Saalfeld et al. 2011, 2012). For example, when annual irrigation practices of groundwater pumping coincide with extended drought and surface water evaporation, surface water is very ephemeral. Predictions of increasing evaporation rates in models of future climate change will further reduce hydroperiods in saline lakes, which are considered to be at "regionally high risk" of alteration under current climate change models (Matthews 2008).

In saline lakes, rooted vascular plants are typically restricted to close proximity to remnant artesian spring discharge zones, leaving most of the basin floor without vegetation. Due to their inhospitable environments, saline lakes possess a fraction of the floral diversity of playas (Rowell 1971; Haukos & Smith 1997) and provide habitat for more specialized avian fauna than playas (Iverson et al. 1985; Conway et al. 2005 a, b; Andrei et al. 2008; Saalfeld et al. 2011, 2012). For saline lakes, much of the basic biological inventory and natural history data are lacking. The purpose of the research reported here is to provide an annotated checklist of vascular plants collected from accessible saline lakes in the SHP of Texas and eastern New Mexico.

METHODS

The SHP is an approximately 80,000 km^2 region occurring from the panhandle of Texas (south of the Canadian River), into New Mexico (east of the Pecos River), and south to Midland, Texas, at a regional elevation of approximately 1000 m (Osterkamp & Wood 1987). Level topography is broken by shallow freshwater playa

wetlands; draws; and large, deep, saline lakes. Although playas numerically dominate, approximately 40 saline lakes also occur; and combined, these features comprise the regionally dominant wetland systems. Regional annual precipitation averages approximately 45 cm/yr, with annual evaporation exceeding 200 cm/yr, as summer temperatures may reach 40°C. Within saline lakes, temperatures fluctuate diurnally during summer, ranging from 7–54°C (Saalfeld et al. 2012). The growing season in the region ranges from 193–287 days (NRCS 2000).

We acquired access to seven individual SHP saline lakes (Fig. 1). Three on private lands (Mound Lake, Rich Lake, and Tahoka Lake) are considered to be the best remaining saline lakes (Saalfeld et al. 2011, 2012) as they maintain some surface water with seasonally functional artesian springs. An additional three lakes (Goose Lake, Paul's Lake, and White Lake) are located on the Muleshoe National Wildlife Refuge and possess less regular spring flow. Grulla Lake, on the Grulla National Wildlife Refuge, no longer contains flowing artesian springs. Processes by which these lakes have formed have been widely debated, but recent work, via core sampling of lake basins, indicates some basin sediments are more than 300,000 years old (Wood 2002). Most saline lakes contain aeolian deposited lunettes on the lee side of the basin, consisting of fine lacustrine sediments, deposited when saline lakes are dry (Wood 2002). As the basin floor of saline lakes were historically connected to the top of the Ogallala Aquifer, soils of the basin are typically hydric loamy lacustine deposits (NRCS 2000) in form, and in some instance may be greater than 30 m deep, reflecting some aeolian deopposition on basin floors during periods of extended dry conditions (Wood 2002). Soils surrounding artesian springs, in which we focused our floristic surveys, tend to be sandier and overlay the hydric loamy lacustrine soil mentioned above.

Collecting trips were made to these saline lakes (Table 1) in 2009 from May 25th-28th and again from September 18th-19th. For reasons mentioned, collecting was focused near artesian spring discharge zones within the lake basins that we were confident experienced current or historical seasonal flooding. A complete set of voucher specimens is housed at the University of Texas at Austin Plant Resources Center Herbarium (TEX).

RESULTS AND DISCUSSION

This research resulted in a collection of 49 species of vascular plants representing 16 families and 40 genera (Table 2). The four families with the most species were Asteraceae (12), Amaranthaceae (8), Cyperaceae (5), and Poaceae (12). Non-native species (*Bromus catharticus*, *Poa compressa*, *Polypogon monspeliensis*, *Sonchus oleraceus*, *Kochia scoparia*, and *Tamarix ramosissima*) accounted for 10% of the total species. Overall species richness within each lake, excluding Tahoka Lake, was poor, only ranging from 3–14 species (Table 1). Tahoka Lake contained 43 of the 49 species identified during the surveys, and 21 species that were not collected from any other saline lake (Table 2). Mound, Goose, and Grulla Lakes contained one unique species each, while Rich Lake contained three (Table 2). The only species common to all saline lakes was the exotic invasive *Tamarix ramosissima* (Table 2).

Reasons for disparities in species richness among saline lakes may be related to historical anthropogenic alterations and surrounding land use practices. Each saline lake is bordered by some combination of upland grasslands, row crop agriculture, or former cropland planted to exotic perennial grasses under the U.S. Department of Agriculture, Conservation Reserve Program. Row crop agriculture impacts local hydrology via groundwater pumping for irrigation. To date, no studies have been performed to estimate water use of these areas surrounding each basin. Nonetheless, Tahoka Lake remains the least impacted saline lake because no anthropogenic alterations nor any petrochemical exploration has occurred on the lake basin bottom (unlike Mound and Rich lakes). Tahoka Lake still contains three functional artesian springs, located at the north, west, and southwestern boundaries of the lake basin. Although spring flow is more intermittent now than in the past (Conway et al. 2005 a, b; Saalfeld et al. 2011, 2012), it maintains the plant richness reported herein. On its northeastern border, Mound Lake contains several small seeps and one dominant spring surrounded by a *Bolboschoenus maritimus* subsp. *paludosus* dominated marsh (Fig. 2). A long history of petrochemical development on the north and south sides of the lake have probably impacted other springs. Rich Lake contains only

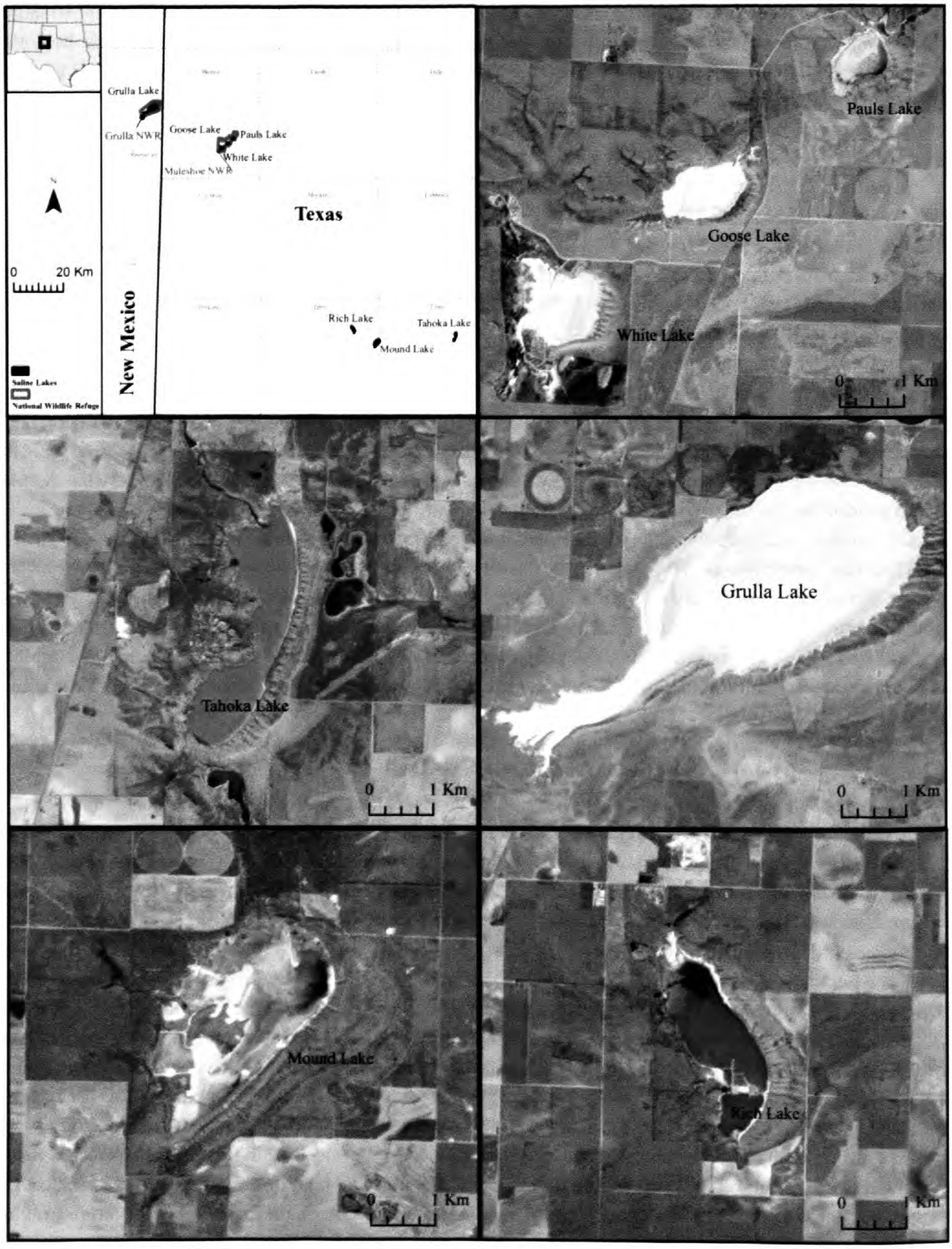


FIG. 1. Location and satellite imagery of saline lakes surveyed in the Southern High Plains of Texas and eastern New Mexico, May and September, 2009.

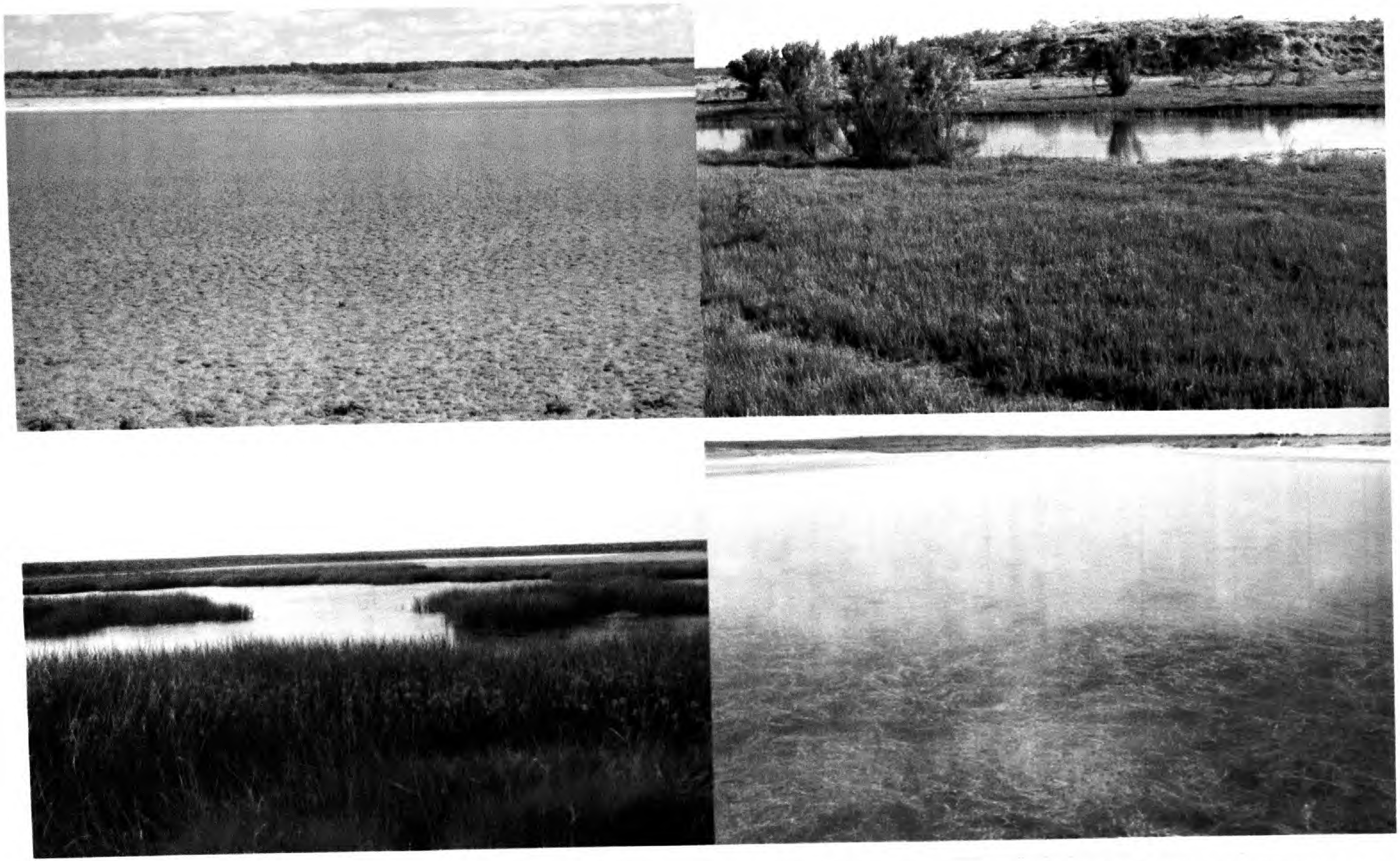


Fig. 2. **Top left:** General aspect of saline lakes of the SHP showing largely un-vegetated basin floor (Tahoka Lake). **Top right:** *Distichlis spicata* meadow, Tahoka Lake. **Bottom left:** *Bolboschoenus maritimus* subsp. *paludosus* marsh (with *D. spicata* in the foreground), Mound Lake. **Bottom right:** Submerged bed of *Ruppia maritima*, White Lake.

TABLE 1. Size, location, and species richness of saline lakes surveyed in the Southern High Plains of Texas and eastern New Mexico, May and September, 2009.

	Size (ha)	Lat/Lon	County, State	Richness
Goose Lake (G)	90	33° 57′ 37″ N 102° 44′ 37″ W	Bailey Co., TX	4
Grulla (Gr)	875	34° 5′ 23″ N 103° 4′ 27″ W	Roosevelt Co., NM	3
Mound Lake (M)	600	33° 13′ 42″ N 102° 4′ 52″ W	Terry Co., TX	14
Paul's Lake (P)	70	33° 58′ 47″ N 102° 43′ 11″ W	Baily Co., TX	10
Rich (R)	270	33° 16′ 37″ N 102° 11′ 46″ W	Terry Co., TX	10
Tahoka Lake (T)	285	33° 14′ 58″ N 101° 44′ 49″ W	Lynn Co., TX	43
White Lake (W)	135	33° 56′ 33″ N 102° 46′ 7″ W	Baily Co., TX	6

TABLE 2. Checklist of the vascular flora saline lakes surveyed in the Southern High Plains of Texas and eastern New Mexico, May and September, 2009. (Goose Lake = **G,** Grulla Lake = **Gr,** Mound Lake = **M,** Paul's Lake = **P,** Rich Lake = **R,** Tahoka Lake = **T,** and White Lake = **W**). Collection numbers are the first author's. Non-native species are indicated by an asterisk (*) based on review of Correll & Johnston (1970). Species not recorded from playas are indicated by superscript dagger (†) based on review of Rowell (1971), Smith & Haukos (2002), and Haukos & Smith (1997).

Aizoaceae

†*Sesuvium verrucosum* Raf., **GGrPRTW** 4897, 4926, 4943, 4948, 4953, 4957

Amaranthaceae

†*Atriplex canescens* (Pursh) Nutt., **MT** 4927, 4972
†*Atriplex subspicata* (Nutt.) Rydb., **T** 4988
Chenopodium berlandieri Moq., **T** 4986
Kochia scoparia* (L.) Schrad., **MPTW 4987, 5004, 5009, 5011
†*Salicornia rubra* A. Nelson, **Gr** 4947
†*Suaeda depressa* (Pursh) S. Watson, **MT** 4998, 4999
†*Suaeda nigra* (Raf.) J.F. Macbr., **TP** 4990, 5010
†*Suaeda suffrutescens* S. Watson, **T** 4975

Asteraceae

†*Ambrosia confertiflora* DC., **MT** 4982, 5002
Baccharis salicina Torr. & A. Gray, **MT** 4976, 5001
Conyza canadensis (L.) Cronquist, **T** 4983
Grindelia ciliata (Nutt.) Spreng., **T** 4985
†*Grindelia nuda* Alph. Wood var. *nuda*, **T** 4994
Helianthus petiolaris Nutt., **T** 4991
Machaeranthera tanacetifolia (Kunth) Nees, **T** 4984
Pluchea purpurascens (Sw.) DC., **MT** 4979, 5003
Sonchus oleraceus* L., **M 4922
Symphyotrichum divaricatum (Nutt.) G.L. Nesom, **MT** 4978, 5005
†*Xanthisma spinulosum* (Pursh) D.R. Morgan & R.L. Hartm. var. *spinulosum*, **R** 4936
Xanthium strumarium L., **T** 4997

Boraginaceae

Heliotropium curassavicum L. var. *curassavicum*, **TP** 4899, 5012

Convolvulaceae

†*Cressa truxillensis* Kunth, **GPTW** 4894, 4941, 4954, 4958

Cyperaceae

Bolboschoenus maritimus L. (Palla) subsp. *paludosus* (A. Nelson) T. Koyama, **MPRT** 4909, 4925, 4933, 4945
†*Eleocharis rostellata* (Torr.) Torr., **T** 4896
Schoenoplectus americanus (Pers.) Volkart ex Schinz & R. Keller, **T** 4910
†*Schoenoplectus pungens* (Vahl) Palla var. *longispicatus* (Britton) S.G. Sm., **RT** 4915, 4934
Schoenoplectus tabernaemontani (C.C. Gmel.) Palla, **PMT** 4923, 4944, 4962

Gentianaceae

†*Eustoma exaltatum* (L.) Salisb. ex G. Don, **T** 4996

Juncaceae

Juncus torreyi Coville, **T** 4960

Malvaceae

Malvella leprosa (Ortega) Krapov., **G** s.n.

Onagraceae

†*Gaura parviflora* Douglas ex Lehm., **T** 4992

Poaceae

Bromus catharticus* Vahl, **R 4935
Distichlis spicata (L.) Greene, **MPRT** 4898, 4924, 4931, 4940
Elymus canadensis L. var. *canadensis*, **T** 4959
†*Elymus elymoides* (Raf.) Swezey subsp. *brevifolius* (J.G. Sm.) Barkworth, **R** 4937
Hordeum jubatum L. subsp. *jubatum*, **PRT** 4913, 4932, 4946
Hordeum pusillum Nutt., **T** 4906
Panicum obtusum Kunth, **T** 4993
*†*Poa compressa* L., **T** 4901
Polypogon monspeliensis* (L.) Desf., **RT 4902, 4930
Sporobolus airoides (Torr.) Torr., **TW** 4971, 5008
†*Sporobolus texanus* Vasey, **MT** 4980, 5000
†*Tridens muticus* (Torr.) Nash var. *elongatus* (Buckley) Shinners, **T** 4905

Polygonaceae

Polygonum ramosissimum Michx., **T** 4989

Potomogetonaceae

Zannichellia palustris L., **T** 4908

Ruppiaceae

Ruppia maritima L., **PTW** 4907, 4939, 5007

Tamaricaceae

Tamarix ramosissima* Ledeb., **GGrMPRTW 4895, 4926, and sight records

Typhaceae

Typha domingensis Pers., **MT** 4974, 5006

one primary spring on the northwestern margin of the basin, now dominated by *Tamarix ramosissima*, and extensive alteration (i.e., dikes and levees) on its southern side. Grulla Lake no longer has any functional springs, and had the poorest richness found in this study. Two Muleshoe NWR Lakes (Goose and White) also have very intermittent springs, where discharge occurs only during the early growing season. Conversely, Paul's Lake has remained flooded for an extended period of time, as removal of *T. ramosissima* in this basin has apparently allowed spring flow to recover. However, all three Muleshoe saline lakes contain an elevated levee partitioning each lake. Constructed as Work Projects Administration (WPA) projects to improve water retention in a portion of each basin, these levees have dramatically altered water flow in each lake, effectively creating two different systems within each basin; one with some spring flow, the other without. As no rooted plants exist on any saline lake basin, except in close proximity to artesian springs, the floral richness among lakes reflects the importance of maintaining springs and minimizing impacts to individual lake basin hydrology.

Saline lakes contain slightly more than 10% of the species richness of playas (approximately 350 species [Rowell 1971; Haukos & Smith 1997; Haukos & Smith 2004]). Nineteen species collected from saline lakes have not been reported from playas (Table 2). Dominant species of the saline lakes we surveyed are similar to those described for temperate desert wetlands of the Intermountain Region of Western North America and occur in well defined zones in response to topographic gradients (West & Young 2000). We observed *Distichlis spicata* to form a "meadow" in seasonally saturated to very shallowly flooded soils. Whereas an emergent marsh of *Bolboschoenus maritimus* subsp. *paludosus* or submerged "beds" of *Ruppia maritima* occur where surface water is deeper and persists longer (Fig. 2). These species (and a few interstitial species in our checklist) are also known to be important members of saltmarsh communities of the temperate and tropical Gulf Coastal Plain. Two other species we recorded, *Suaeda nigra* and *Sporobolus airoides*, are listed as important members of lowland salt-desert shrub communities of all four North American deserts (West & Young 2000). More work is needed to better understand the floristic relatedness of saline lakes of the SHP to other halophytic plant communities of North America.

This survey represents the first attempt to characterize saline lake flora of the SHP of northwest Texas and eastern New Mexico. Since the survey in 2009, the region has been experiencing an extended drought, which has at least temporarily altered the flora in some of these lakes, Tahoka Lake in particular. Reductions in spring flow, even in these saline lakes that maintain some artesian flow, combined with little or no precipitation, may permanently alter this distinctive regional flora. These wetlands are unique systems and provide virtually the only nesting habitat for snowy plovers (*Charadrius nivosus*) in the region (Conway et al. 2005 a, b; Saalfeld et al. 2011, 2012). This survey provides further evidence of the importance of freshwater spring conservation in SHP saline lakes.

ACKNOWLEDGMENTS

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ECOLOGY AND DISTRIBUTION OF THE NORTH CENTRAL TEXAS ENDEMIC *DALEA REVERCHONII* (FABACEAE)

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ABSTRACT

Thirty-three new populations of *Dalea reverchonii* (Comanche Peak Prairie Clover) are reported from five additional counties in north central Texas: Bosque, Erath, Johnson, Somervell, and Tarrant counties. This expands the distribution of this Texas endemic from three counties to eight at a total of 69 sites. Habitat requirements, associated species, and threats are included and discussed. *Dalea reverchonii* is considered to be globally and state imperiled. The discovery of these additional populations and new county records may warrant modification of its conservation status.

RESUMEN

Se citan treinta y tres nuevas poblaciones de *Dalea reverchonii* (Comanche Peak Prairie Clover) en cinco condados adicionales del centro norte de Texas: condados de Bosque, Erath, Johnson, Somervell, y Tarrant. Esto expande la distribución de este endemismo de Texas de tres condados a ocho con un total de 69 lugares. Se incluyen y discuten los requerimientos de hábitat, especies asociadas, y amenazas. *Dalea reverchonii* se considera en peligro a nivel global y del estado. El descubrimiento de estas poblaciones adicionales y citas en condados nuevos podría justificar la modificación de su status de conservación.

INTRODUCTION

Dalea reverchonii (S. Watson) Shinners was described in 1886 by Sereno Watson from an 1882 collection made by Julien Reverchon (*1273*, GH, NY, SMU, US) "on the rocky top of Comanche Peak" (Watson 1886), Hood County, Texas. Eggert recollected the species from Comanche Peak in 1900 (Mahler 1984). Several botanists have attempted to relocate the type locality on Comanche Peak but were unable to find any plants (Orzell 1987). In 1964 Barneby collected *D. reverchonii* in "limestone breaks" near Springtown in Parker County (*Barneby 13529*, NY). This collection represented the first time the species had been seen in 64 years. Mahler relocated this population in 1984 (*Mahler 9594*, SMU) and found several new locations in Parker and Wise counties (Turner 1959; O'Kennon 2010). Mahler (1984) recorded eight populations of *D. reverchonii* in 1984 but noted that "the actual observed populations are thought to reflect only a small percentage of the total number possible within the Grand Prairie." Barneby (1977) agreed with this sentiment saying "the species must be expected to turn up elsewhere around the northern fringes of Edwards Plateau."

Several surveys have been completed documenting the range of *Dalea reverchonii*, including Orzell (1987), Singhurst and Horner (1997), and McLemore and O'Kennon (2003). As of 2003 there were a total of 36 known populations, the majority of which were in Parker County. The population south of Springtown, which was discovered by Barneby, was estimated at over 1000 plants and was virtually destroyed by road widening, with only 23 plants remaining in 2003 (McLemore & O'Kennon 2003). In 2003, McLemore and O'Kennon relocated the type locality on the top of Comanche Peak for the first time in 103 years, where they found 11 plants (*O'Kennon & McLemore 18793*, BRIT).

Dalea reverchonii is a calciphile, known to grow only on rocky limestone substrate Cretaceous in age. Mahler (1984) described the habitat as "thin soil overlying limestone rock." Orzell (1987) noted that plants were found growing on a "nearly flat Goodland Limestone (Cretaceous Age) Glade surrounded by shrub thickets" (*Orzell 5581*, TEX). O'Kennon (2010) and Swadek and Burgess (2012) disagreed on the type of geology,

noting that the species is restricted to Walnut Limestone glades. Much of the Walnut (Kwa) and Goodland (Kgl) limestones are mapped as undivided units (i.e. Kgw), possibly leading to the uncertainty in geology. Comanche Peak, the type locality for the species, is topped with Edwards Limestone (Ked). *Dalea reverchonii* has only been collected in limestone substrate on what have been termed limestone glades by Swadek and Burgess (2012). These glades consist of little to no soil overtopping limestone bedrock.

As of 2003, this rare Texas endemic was only known from Hood, Parker, and Wise counties in Texas. *Dalea reverchonii* has a conservation rank of G2S2 (globally and state imperiled) indicating the species is at high risk of extinction "due to very restricted range, very few populations, steep declines, or other factors" (NatureServe 2013). The recent discovery of additional sites for several associate species suggests the possibility of finding additional *D. reverchonii* populations (Swadek & Burgess 2012; Taylor et al. 2012). Mahler (1984) believed "continued field research will undoubtedly produce more populations." The purpose of this study was to update the status of *D. reverchonii*, by surveying for additional populations and providing a thorough description of *D. reverchonii* habitat, including underlying geology and associated species.

METHODS

In 2011 the authors began an updated status survey of *Dalea reverchonii*. All known sites were revisited from spring 2011 through fall 2012 and population numbers were estimated. Associated species, geology, and habitat preferences were recorded. Satellite imagery and geologic maps were used to locate limestone outcrops representing habitat similar to that seen on known sites across nine north central Texas counties. All potential suitable habitat identified was searched for additional populations.

RESULTS AND DISCUSSION

Dalea reverchonii was found at 33 additional sites across eight north central Texas counties (Fig. 1). This brings the total number of sites to 69 and represents new county records for Bosque, Erath, Johnson, Somervell, and Tarrant counties. Population sizes ranged from one to several thousand plants, though most sites had fewer than 100 plants. The Aurora sites in Wise County were the largest population, consisting of an extensive system of linked glades. Each of the approximately 10 glade groups in the Aurora complex was estimated to have over 1000 plants. Population numbers are largest in Wise and Parker counties, with the populations in Bosque, Erath, Hood, Johnson, Somervell, and Tarrant counties typically consisting of fewer than 10 plants. Associated species include *Minuartia michauxii* (Fenzl) Farw. var. *texana* (B.L. Rob. ex Britton) Mattf., *Phemeranthus calycinus* (Engelm.) Kiger, *Sporobolus vaginiflorus* (Torr. ex Gray) Wood, *Hedyotis nigricans* (Lam.) Fosberg, *Heliotropium tenellum* Torr., *Hedeoma drummondii* Benth., *Plantago helleri* Small, *Erioneuron pilosum* (Buckley) Nash, *Opuntia phaeacantha* Engelm. var. *major* Engelm., *Tetraneuris scaposa* (DC.) Greene, and *Croton monanthogynus* Michx. Less common associates include *Pediomelum reverchonii* (S. Watson) Rydb., *Coryphantha sulcata* (Engelm.) Britton & Rose, *Dalea frutescens* A. Gray, *Bouteloua pectinata* Feath., *Paronychia virginica* Spreng., and *Yucca pallida* McKelvey. From Hood County southward, the following species were typically associated with *D. reverchonii*: *Erigeron modestus* A. Gray, *Linum rupestre* (A. Gray) Engelm. ex A. Gray, *Thelesperma simplicifolium* (A. Gray) A. Gray, *Verbena canescens* Kunth var. *roemeriana* L.M. Perry, *Vernonia lindheimeri* A. Gray & Engelm., and *Melampodium leucanthum* Torr. & A. Gray.

Dalea reverchonii appears restricted to crevices in exposed limestone bedrock, very shallow soils over bedrock, or Walnut marl where the shell hash has been removed (Fig. 2). The roots are embedded in the Walnut marl directly below the indurate *Texigryphaea mucronata* shell hash. The plant was rarely seen where vegetative cover is taller and denser, which seems to be associated with deeper soils overlying the limestone. The closely related limestone cedar glade endemic *Dalea gattingeri* (A. Heller) Barneby has high light requirements and poor competitive ability, suggesting the species is endemic to limestone glades of Tennessee, Alabama, Georgia, Missouri, and Arkansas not because it prefers the habitat but because it is not shaded and outcompeted by other taxa (Breeden 1968). It is likely that *D. reverchonii* is restricted to limestone glades for similar reasons. Gankin and Major (1964) concluded that rare plants often occur in areas where light competition

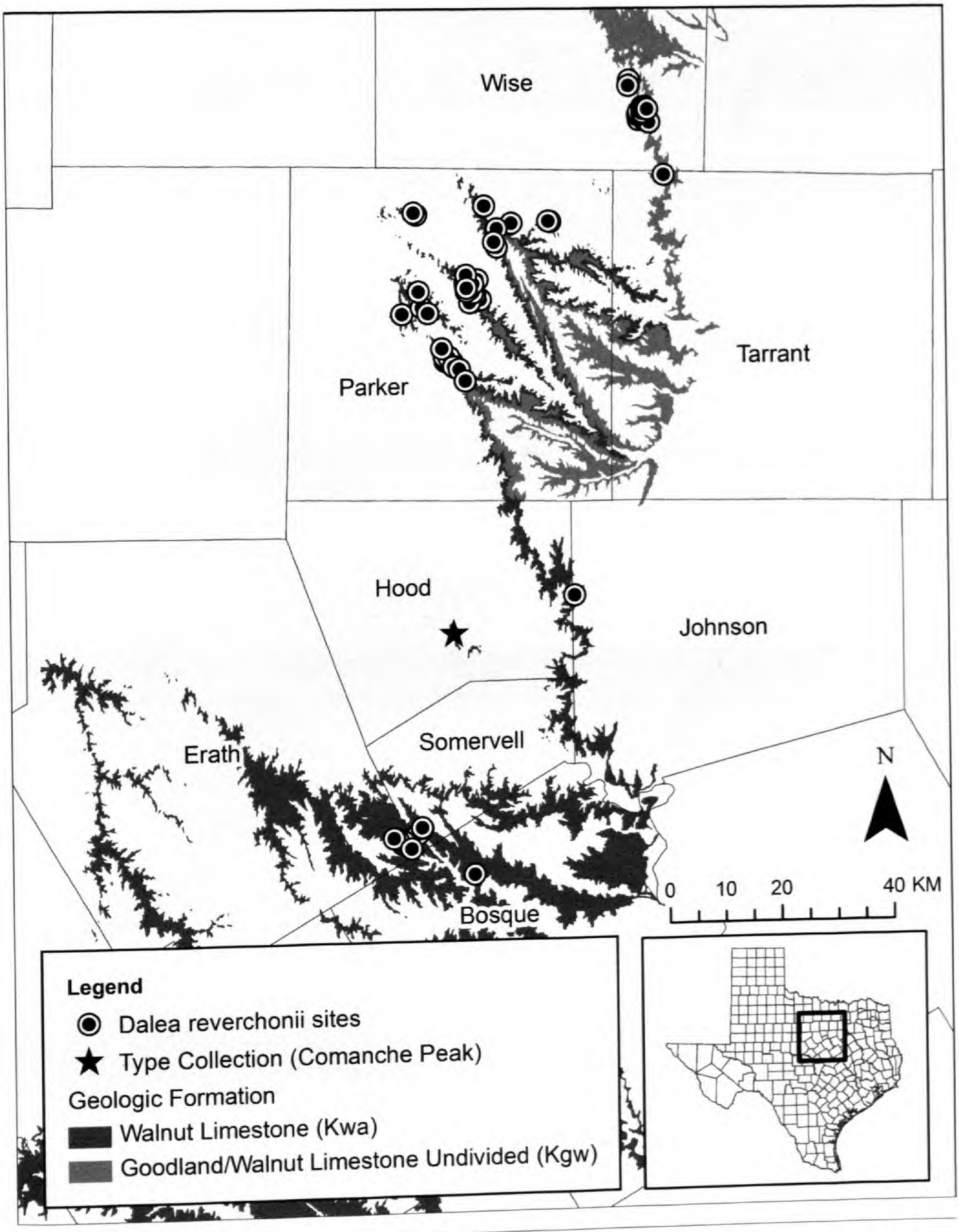


FIG. 1. Distribution of *Dalea reverchonii* in north central Texas. Thirty-three new populations were found including five new county records (Bosque, Erath, Johnson, Somervell, and Tarrant).

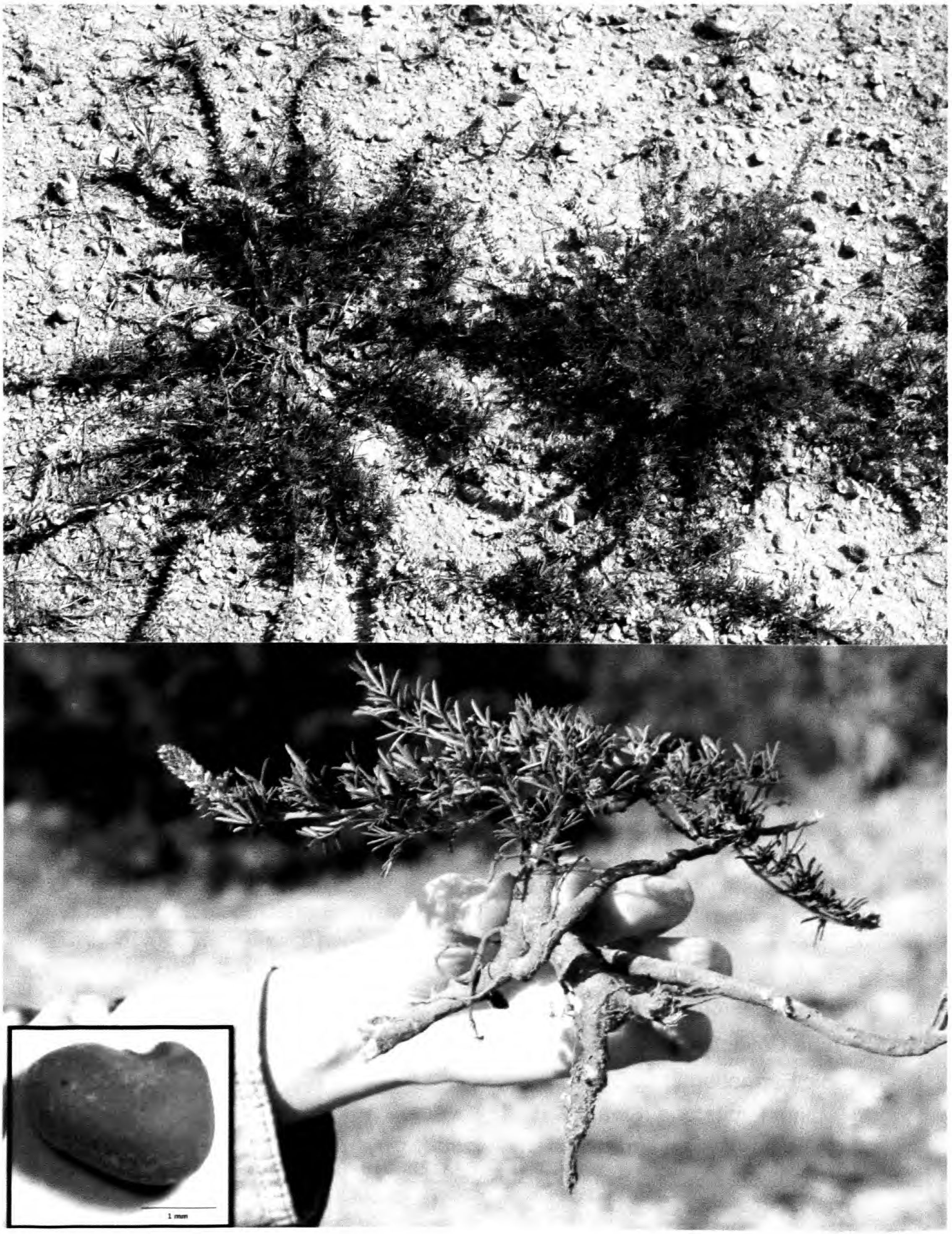


Fig. 2. **Top** – *Dalea reverchonii* plants showing prostrate habit of older plants (left) and more erect habit of younger growth (right). Photo taken 7 May 2011, New Highland Rd. site, Parker County. **Bottom** – *Dalea reverchonii* plant showing woody taproot and seeds (inset). Seeds have a hard coat and are 1.7 × 2.7 mm. Photo taken 11 Nov 2011, Summit Ridge glade site, Parker County.

from associated vegetation is decreased "by some extraordinary soil parent material . ..." (Baskin & Baskin 1988).

All *Dalea reverchonii* populations, with the exception of the Comanche Peak site, were found on texigryphaeid oysterbeds of the Walnut Limestone Formation (Fig. 3). In the northern and western parts of its range *D. reverchonii* sites tend to be on higher parts of the landscape, appearing as erosional remnants capping the softer Paluxy Sandstone below. In the southern and eastern parts of its range *D. reverchonii* tends to be at lower parts of the landscape where the softer Goodland/Comanche Peak Limestone or clays in the Fredericksburg group erode away exposing the harder Walnut caprock below. Therefore, *D. reverchonii* is typically found at the edges of the Walnut Formation near the contact with either the underlying or overlying strata. Thicker soil development above the hard *Texigryphaea* oyster beds, and the associated taller vegetation, rarely support the plant. Therefore populations will only be stable in areas where the bedrock remains exposed forming an edaphic climax community. This explains why the plant is not found further to the south on the Edwards Plateau where the Walnut Formation is quite expansive but is typically located in valleys and supports more developed soils. A few *D. reverchonii* sites were found where soil development was more advanced, and the plants were overtopped by annual and perennial grasses. These sites have likely progressed from open glades to deeper-soiled barrens as described by Quarterman (1950) for the cedar glades of central Tennessee. *Dalea reverchonii* could potentially persist for some time in glades where it was well established that have become overgrown, but population numbers would be expected to decline, ultimately resulting in extirpation from the site.

The *Dalea reverchonii* population from the top of Comanche Peak (Fig. 4) is the only known location for the species not in Walnut Limestone. The type locality is actually in thin soil on Edwards Limestone near the contact with Comanche Peak Limestone (very similar to Goodland Limestone to the North of Hood County) and far from (60 meters above) the Walnut Limestone. The peak base is surrounded by Walnut Limestone with an abundance of exposed bedrock similar to that at other *D. reverchonii* sites. This area is currently grazed by cattle which may explain the plant's absence from this otherwise ideal habitat. We hypothesize that the Walnut Limestone surrounding Comanche Peak historically supported a large population of *D. reverchonii*. The plants on the top of Comanche Peak were likely opportunistic and only survived due to the difficulty for cattle to reach them. The Comanche Peak population suggests that it is not the chemical makeup of the Walnut Limestone that determines the plants viability, but the edaphic conditions that the hard erosion-resistant caprock produces. These mesas capped with Edwards Limestone, which are similar to the cuestas of the Grand Prairie capped with Walnut Limestone, are abundant throughout the Lampasas Cut Plain south of Hood County (Hill 1901). These areas are mostly privately held ranch land and may represent an unexplored habitat for the species.

On surfaces stabilized by a caprock glade of Walnut Limestone, the vegetation tends to be lower, more open, and less grassy than typical mixed grass prairies. This vegetation may be part of the "Walnut Prairie" described by Hill (1901), which he recognized as distinct from the Fort Worth Prairie. This community should not be confused with mixed grass prairies, especially since it has at least one endemic plant species. It would promote greater awareness of the vegetation differences and appreciation of the unique geologic qualities if these landscape units were distinguished by some label other than "prairie." The processes structuring the vegetation seem to conform with the concept of glades and barrens described by Quarterman (1950).

Swadek and Burgess (2012) proposed the open rocky areas where *D. reverchonii* thrives be termed "Walnut Limestone glades." Proposing a name for the unique landscape and community that this species inhabits would aid stewards of environmental heritage in promoting the appreciation and conservation of this distinctive regional ecosystem. Swadek and Burgess (2012) define a Walnut Limestone glade as "open areas of exposed limestone outcrops and rocky areas with soils around 0 to 5 cm deep. *Texigryphaea* fossil shell fragments usually dominate surfaces."

These Walnut Limestone glades are both structurally and floristically "reminiscent of those found in the Central Basin of Tennessee" (Taylor et al. 2012). *Dalea gattingeri* fills the same ecological niche in the Tennessee



Fig. 3. Typical *Dalea reverchonii* habitat, Rocky Walnut Limestone glade with thin soil over exposed bedrock. Photo taken 24 Apr 2011, Utley site, Parker County, Texas.

cedar glades as *D. reverchonii* does in the Walnut Limestone glades. Both species in Series Purpureae thrive in shallow soil and cracks in exposed limestone bedrock (Barneby 1977). Baskin and Baskin (1988) suggest that marginal populations of widespread species, through catastrophic selection, "could result in narrow edaphic endemics...[and] may have played a role in the evolution of some of the rock outcrop endemic taxa, especially those that are closely related to widely distributed taxa within their geographic region." Both *D. gattingeri* and *D. reverchonii* are on the margins of the geographic range of the closely related *D. purpurea* Vent. Catastrophic selection in marginal *D. purpurea* populations may have resulted in the evolution of both limestone glade endemic taxa.

Several threats exist to *Dalea reverchonii* including road widening, land development, spread of non-native plants, and livestock grazing. Perhaps the most severe threat is that of grazing by livestock. Other than the populations concentrated in Weatherford city limits, the majority of *D. reverchonii* sites remain in rural areas where land beyond the right-of-way has not been subdivided or platted. Much of *D. reverchonii*'s habitat remains rangeland and often appears ungrazed or only lightly grazed. Plants were rarely found in locations where livestock were present. In some cases, several plants would be found on the roadside but no plants would be found inside the fence where livestock were present. The plants do appear to be able to persist with mild grazing, but we predict that repeated intense grazing will ultimately result in the death of the large woody taproot and the death of the plant. The Aurora sites in Wise County are mildly grazed, but it appears the cattle tend to stay at higher elevations where vegetation is more abundant. The species was likely much more abundant prior to the 1800s when extensive conversion of land to pastures likely led to the destruction of many populations.

Non-native invasive taxa prove a threat to the species through competition and shading. Equally, prevent-



Fig. 4. Bob O'Kennon with *Dalea reverchonii* at the type locality on the top of Comanche Peak. Prior to 2003 the species had not been seen at this location since 1900. Photo taken 1 Aug 2003, Comanche Peak site, Hood County, Texas.

ing woody encroachment into the glades will be essential in maintaining viable populations. *Dalea reverchonii* appears to thrive in sites where the Walnut caprock has been removed, leaving the softer underlying marl exposed. These quarried sites appear to be well suited for *D. reverchonii* as scraping removes competing vegetation and the hard shell hash, allowing roots easy access to the Walnut marl. It is unclear if this success will persist as soils may develop and competing vegetation invade with the absence of the hard rock shell hash.

In 2005, *Dalea reverchonii* plants were transplanted to three locations in the Lyndon B. Johnson National Grasslands in Wise County. The plants that were introduced are thriving, but no new plants have come up from seed. This lack of recruitment is likely due to the hard seed coat (Fig. 2), but could have implications for establishment of new viable populations. An additional population was planted in the Fort Worth Nature Center and Refuge in Tarrant County in 2012. All reintroduced populations were planted on Walnut Limestone glades. It is likely that *D. reverchonii* plants would have historically occurred at both the LBJ National Grasslands and Fort Worth Nature Center and Refuge. A history of livestock grazing at both locations could explain their current absence from these locations. These transplanted populations represent the only populations on city, state, or federally protected land. *Dalea reverchonii* currently has a conservation rank of G2S2, but with this recent range expansion this rank may warrant modification.

Representative voucher specimens: **USA. TEXAS. Bosque Co.:** CR 2650 at Cr 2640, ca 1.5 mi W of Walnut Springs, hard pack limestone in fence line, 2 plants, 32.057893, -97.775105, elev. 284 m, 30 May 2011, *O'Kennon 23497* (BRIT). **Erath Co.:** Rough Creek Lodge, Co Rd 2013 ca 4.2 mi SE of hwy 67, 10.4 mi SW of Glen Rose, growing on Walnut Limestone glade, 32.099184, -97.890129, elev. 334 m, 25 Nov 2011, *O'Kennon 24574* (BRIT). **Hood Co.:** Comanche Peak. 4.5 mi S of Granbury, growing in thin, rocky soil over Edwards Limestone on rocky top of Comanche Peak, plants prostrate to the ground, 11 plants observed, collected from type locality. 32.381812, -97.803996, elev. 369 m, 5 Aug 2003, *O'Kennon & McLemore 18793* (BRIT); 7 plants observed, 4 May 2011, *Norton, O'Kennon, Kieschnick, Barfield, & Swadek 734* (BRIT). **Johnson Co.:** Intersection of Cleburne Hwy and Running Deer Ct, 4.9 mi E of Acton, growing on Walnut Limestone glade, 32.427929,

-97.616031, elev. 239 m, 10 Dec 2011, *O'Kennon 24597* (BRIT). **Parker Co.:** Corner of Highland Rd and New Highland Rd, ca 3 mi SW of Springtown, plants growing prostrate to the ground, very abundant, 32.927577, -97.648501, elev. 309 m, 6 May 2011, *Norton & O'Kennon 790* (BRIT). **Somervell Co.:** Rough Creek Lodge, Co Rd 2013 ca 4.2 mi SE of hwy 67, 10.4 mi SW of Glen Rose, growing on Walnut Limestone glade, 32.12214, -97.85769, elev. 324 m, 1 Dec 2011, *Norton & O'Kennon 1286* (BRIT). **Tarrant Co.:** FM 718 ca 1.5 mi SE of Newark on S side of rd, growing on Walnut Limestone glade, 4 plants, 32.988185, -97.462911, elev. 224 m, 25 May 2013, *O'Kennon 25829* (BRIT). **Wise Co.:** Private ranch ca 0.8 mi N of Aurora, Walnut Limestone glade, abundant, 33.070957, -97.495660, elev. 252 m, 8 May 2012, *Norton & O'Kennon 1691* (BRIT).

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IN MEMORIAM
REMEMBERING RUTH SCHOTT O'BRIEN
1921–2012

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Ruth O'Brien, native plant specialist and curator of the Ruth O'Brien Herbarium located on the campus of Texas A&M University-Corpus Christi, passed away on December 26, 2012. Ruth was born October 13, 1921, in Sioux City, Iowa. She received her Bachelor of Science degree in Bacteriology in 1945 from the University of Minnesota. Her family relocated to Corpus Christi, Texas in 1949 where she became interested in the native flora of Texas. It was this deep-rooted interest in native plants and taxonomy that led her to complete a Master's of Science degree in Biology from Corpus Christi State University (now TAMU-CC) in 1980. A year after graduating, she founded the university herbarium and became its curator in 1983.

She was interested in the mesquite brush community of plants because they were so adaptive to the area's many environments. Ruth had a thirst for knowledge, and said that her life mission was to pay back her debt to society through teaching and devoting her time and expertise to "her" herbarium. Recently, the Native Plant Society of Texas presented Ruth, Dr. Roy L. Lehman and Tammy White with the Donovan Stewart Correll Memorial Award for scientific writing in the field of native flora of Texas for their book *Plants of the Texas Coastal Bend*. She was also co-author of *Plants of Webb County* and wrote recovery plans for two local endangered

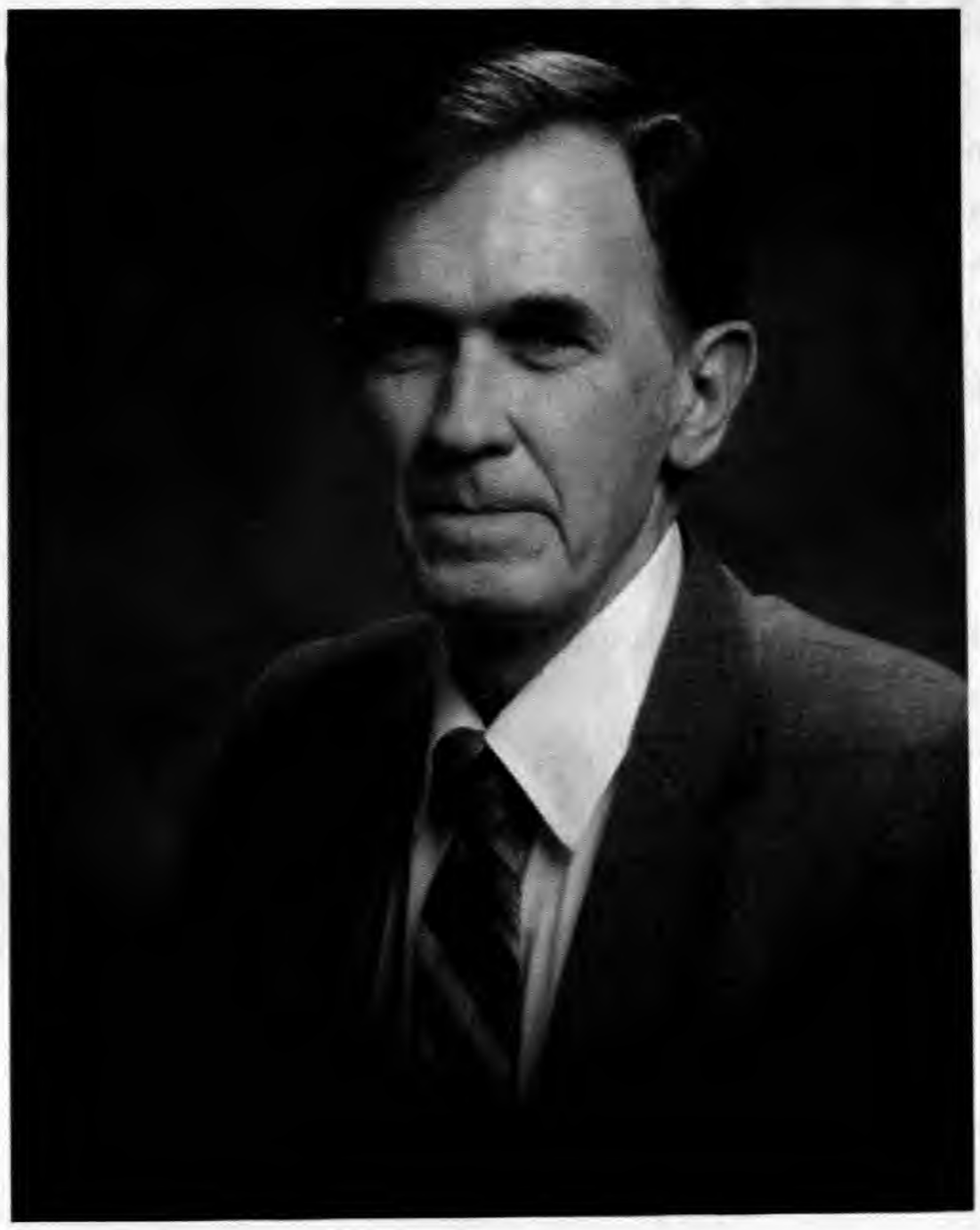
plant species for the U. S. Fish and Wildlife Service. Most of her time was spent at the herbarium identifying plants, answering questions from the public, teaching classes and laboratories and assisting graduate and undergraduate students in plant projects.

She was a member of numerous societies and volunteered many years of service. Most notably were the Botanical Research Institute of Texas, Native Plant Society of Texas, Corpus Christi Museum of Natural History, Corpus Christi Botanical Gardens, Daughters of the American Revolution and American Association of University Women. Through the years, Ruth and her husband, Joe, donated funds to improve the herbarium and, in 2008, started the Joseph A. and Ruth S. O'Brien Endowed Herbarium Internship. The couple also served on the TAMU-CC University President's Council for 18 years and was inducted into the Endowed Scholarship Council in October 2009.

Ruth completed 50 years of volunteer service for the Corpus Christi Museum of Natural History. In recognition, the museum named a wing after her which houses an extensive botanical and shell collection. During her residence at the museum she donated her time as a docent, auxiliary officer, board member and honorary curator of the Museum's herbarium. In addition, she volunteered for over 30 years at the herbarium on the Texas A&M University-Corpus Christi campus that is now named for her. She was a dedicated and talented scientist. Just late last year, I stopped by the university herbarium and there Ruth was, at the age of 91, working with graduate students on plant identifications. She was amazing!

I consider myself fortunate to have worked alongside Ruth for these past 22 years. She was a talented taxonomist that was able to explain to students the difficult details that are necessary to be successful in plant identifications. She had an eager intellect, a kind heart, and a wonderful sense of humor. She will be missed by her students, colleagues and friends.

It is with much affection, admiration and honor that I write these few words for Ruth.



IN MEMORIAM
WILLIAM F. "BILL" MAHLER
1930–2013

The following obituary is reprinted with the family's permission. As Dr. Mahler was especially important to this journal and its parent organization, a special feature by the editors will appear in the next issue. If you would like to contribute a story, a remembrance, an experience, or a fond memory about Wm. F. Mahler, please send to barney@brit.org by 1 October 2013.

William F. "Bill" Mahler, of Iowa Park, Texas, passed away Tuesday, July 2, 2013, at his home. Bill was born August 30, 1930, to Herman & Magdalena (Maier) Mahler on Aldine Street in Iowa Park. He graduated from W.F. George High School in 1947, and attended Hardin College in Wichita Falls, Texas. He served in the U.S. Army from Sept. 1950 to Sept. 1953 with the 14th Ranger Infantry Company (Airborne) at Fort Benning, Georgia; Fort Carson, Colorado; and Friedberg, Germany. In 1954, he returned to college and received his Bachelor's degree in 1955 in Agriculture from Midwestern State University. During this time, he met Wanda Lorene Lindesmith, of Addington, Oklahoma, and they married in January of 1955 in Burkburnett, Texas.

Bill earned his Master's degree in Botany/Plant Taxonomy in 1960 from Oklahoma State University in Stillwater, Oklahoma. For the next six years, he served as an assistant professor at Hardin-Simmons University in Abilene, Texas, where he established the HSU Herbarium. He went on to earn his Ph.D. from the University of Tennessee in Knoxville, Tennessee, in 1968. After graduation, he moved his family to Richardson, Texas, where he joined the faculty of Southern Methodist University in Dallas and assumed directorship of the SMU Herbarium. He became editor and publisher of *Sida, Contributions to Botany* in 1971 and co-editor of *Sida, Botanical Miscellany*. He authored and co-authored many plant taxonomy books & articles, his most popular being the *Shinners' Manual of the North Central Texas Flora* (1984, 1988). For his work, Bill received the Dono-

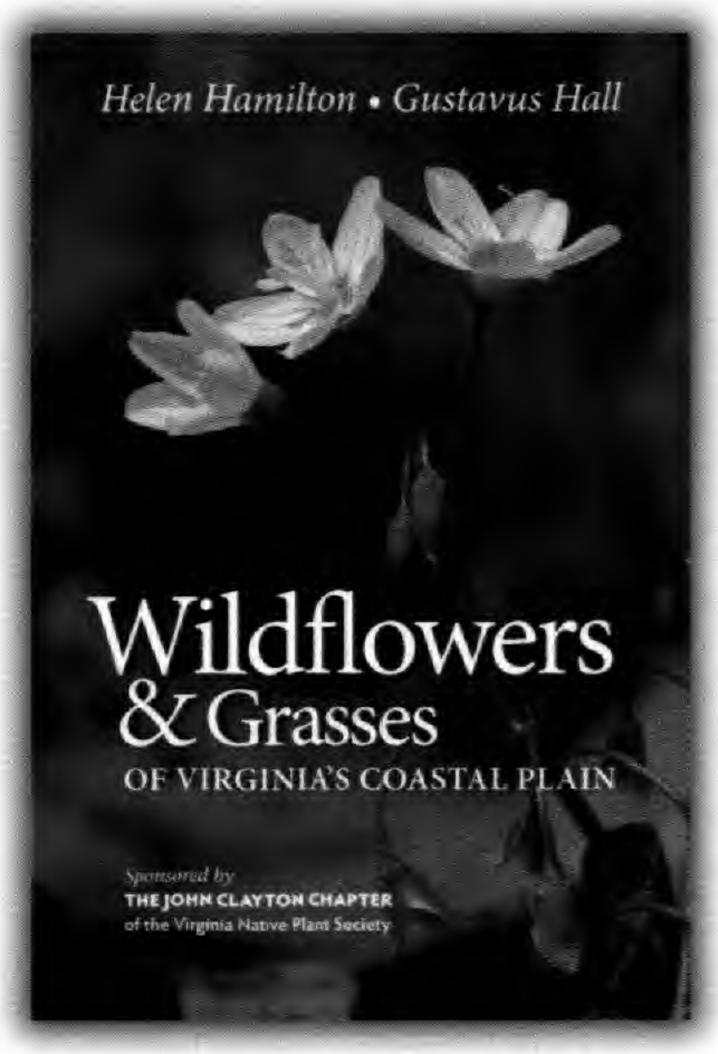
van Stewart Correll Memorial Award for scientific writing on the native flora of Texas in 1991, from the Native Plant Society of Texas. The Native Plant Society of Texas again honored him in 1995 with the Charles Leonard Weddle Memorial Award in recognition of a lifetime of service and devotion to Texas native plants. Bill was a member of many conservation organizations, including the Texas Organization for Endangered Species. He also assisted the National Poison Control Center in identifying mushrooms involved in poisonings.

In his dedication to preserve the SMU Herbarium collection, one of the largest herbarium collections in the world, he worked with Ed Bass [and others] of Fort Worth, Texas, to establish the Botanical Research Institute of Texas (BRIT). After an early retirement from SMU, he served as the first director of BRIT from 1987–1992. In 1992, Bill & Lorene officially retired to his home town of Iowa Park, Texas, where he was an active member of the First United Methodist Church. In his retirement years, Bill enjoyed researching family genealogy and producing family albums with the computer, renewing friendships from childhood and his military days, and being with his family.

Bill is preceded in death by his parents and his brothers, Herman, Jr. and John Edward. He is survived by his wife, Lorene, of 58 years; his daughter, Brenda Cornitius and husband, Tim, of Dodge City, Kansas; his son, Shawn and wife, Carol, of Iowa Park; and five grandchildren: Matthew Cornitius and wife, Victoria, of Dodge City, Kansas; Rebecca Reed and husband, James, of Ft. Riley, Kansas, and Hayley, Jacob, and Nicholas Mahler of Iowa Park.

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Journal of the Botanical Research Institute of Texas

The *Journal of the Botanical Research Institute of Texas*, formerly called *Sida, Contributions to Botany*, publishes research in classical and modern systematic botany—including studies of anatomy, biogeography, chemotaxonomy, ecology, evolution, floristics, genetics, paleobotany, palynology, and phylogenetic systematics. Geographic coverage is global. Articles are published in either English or Spanish; an abstract is provided in two languages. All contributions are peer reviewed and frequently illustrated with maps, line drawings, and full color photographs.

The journal is published twice yearly in a multiple topic format and provides information to scientists, professionals, and the general public for research, education, and cultural enhancement. All articles are indexed and abstracted in print and/or electronic form by the following: AGRICOLA Database (National Agricultural Library); Applied Botany Abstracts: Biosciences Information Service of Biological Sciences (BIOSIS); Current Awareness in Biological Sciences (CABS); ISI Thomson; The Kew Record of Taxonomic Literature: Natural Products Alert (NAPRALERT); Scopus® database, SCImago Journal and Country Rank (Elsevier B.V.); and Referativnyi Zhurnal (Abstracts Journal of the Institute of Scientific Information of the Republic of Russia).

Lloyd H. Shinners, whose herbarium and library were the basis of the Southern Methodist University (SMU) legacy that became BRIT in 1987, founded the journal in 1962. **William F. Mahler** succeeded Shinners as SMU herbarium director in 1971 and inherited both ownership and editorship of the journal. Since 1993, it has been published by the Botanical Research Institute of Texas.

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